THE JOURNAL OF Agricultural Economics Research

United States
Department of
Agriculture

Economic
Research
Service

Contents

Book Reviews

Fall 1988, Vol. 40, No. 4

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The Secretary of Agriculture has determined that the publication of this periodical is necessary in the transaction of public business required by law of this Department. Use of funds for printing this periodical has been approved by the Director, Office of Management and Budget.

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Book Reviews

In This Issue

We close volume 40 with articles analyzing the effects of forecast errors, estimating transition probabilities of a Markov process, and examining stationarity assumptions in supply response. The analyses represent the continuing effort to critique and improve the quantitative underpinnings of the profession's inquiries.

Kolajo, Martin, and Hanson emphasize the value of information in decisionmaking by comparing the accuracy and costs of alternative forecasting methods. They compare farm growth in three financial situations, using one method that optimizes throughout a planning period, and another method that employs serial decisions incorporating previous-year outcomes. They conclude that the method of forming expectations does matter and, furthermore, that the strategy using the expectations can influence the range of errors.

Kim and Schaible address the problem of time series data in Markov processes and challenge the conclusions of other researchers about the appropriate method for estimating transition probabilities. They conclude that a variation of probability-constrained minimum absolute deviations is the superior method when aggregated time series data are used.

Forecasts of future supplies of agricultural commodities are important contributions of economists to the policymaking process. Such forecasts depend on an understanding of the components of change, particularly between growth and cyclical forces. McClelland and Vroomen are concerned that the common practice of treating time statistically as a proxy for growth factors, such as technology, is based on erroneous assumptions of trend stationarity, that is, on cyclical variation without trend. They illustrate with a "simple diagnostic example."

Kilkenny's review of Arndt and Richardson's book on real financial linkages among open economies is enthusiastically favorable. She contrasts the "two camps" of international economists: trade theorists who interpret relative prices in terms of factor endowments, technology, and tastes and macroeconomists who examine interest and exchange rates. The book contains an excellent mix.

Lee notes the paucity of useful empirical work in international trade and says that the book on empirical methods for international trade edited by Feenstra helps fill the gap. The book includes chapters on the Heckscher-Ohlin-Vanek trade models, some industry studies, and a section on duality theory and trade flows. One of Kilkenny's two camps, macroeconomic effects, was inadequately represented in the Feenstra book—a serious limitation in Lee's opinion.

A World Bank book on sustainability issues in agricultural development is critically reviewed by Dovring. Although he admires the candor and directness of some of the contributing authors and commends the objective of knowledge exchange on important development issues, he faults the book on several conceptual issues and its lack of "finish."

Danielson examines a USDA publication on the status of, and prospects for, farmland drainage in the United States, edited by Pavelis. He observes that USDA has been criticized for its pro-agriculture stance on drainage in the past. The book documents the shift in policy toward a balance with environmental values.

We have prepared a new bibliography that lists all articles and reviews published in the Journal since its founding in 1949. You should be receiving it soon. The last bibliography was prepared a decade ago. Libby, the Journal's staff assistant, transformed the references into machine-readable form so that searches can be made on keywords and authors. For more information, give us a call—202-786-1425. We hope the bibliography will be a useful research tool for our readers.

As this volume closes, I want to express my deep appreciation to the many anonymous reviewers who contribute so much to the quality of the Journal. The careful, constructive review of research communication clearly represents the best of the professionalism in research. It would be gratifying to reviewers to see the many complimentary responses of authors who have been helped by serious, even sharp, critiques.

Gene Wunderlich

Forecast Errors and Farm Firm Growth

Ebenezer F. Kolajo, Neil R. Martin, Jr., and Gregory D. Hanson

Abstract. *Researchers should be wary of the expectations framework and optimization method employed when drawing conclusions about the likely production behavior of farmers. The article compares the predictive accuracy of two expectational schemes, supply-based expectations (SBE) and adaptive expectations (ADE), and two modeling approaches, multiperiod linear programming (MPLP) and recursive strategic linear programming (RSLP). Estimated costs of expectational error were sensitive to expectational assumptions and modeling methods. Unanticipated annual revenue gains for the model farm ranged as high as $75,000 for the SBE scheme with the MPLP model, and shortfalls ranged as high as $52,000 for the ADE scheme with the RSLP model. The magnitude of unanticipated gains and shortfalls increased disproportionately with greater use of debt financing.*

Keywords. *Expectational error, mathematical programming, financial leverage, farm growth.*

Profit expectations in farming tend to be stochastic. To the extent that forecast errors reduce profits, prediction is an indirect factor of production. Farm firms are likely to acquire additional "outlook" information so long as its marginal value exceeds its acquisition costs. In this article, we compare the predictive accuracy of alternative expectational schemes. We analyze the cost of expectational errors in relation to alternative modeling approaches for optimizing growth in the net worth of a 600-acre representative Alabama farm raising cotton/soybeans/wheat.

Analysts can better understand the costs associated with input misallocation due to forecast error by reflecting on the developments in U.S. agriculture from the mid-seventies to the mideighties. Demand for agricultural inputs dramatically increased in the seventies in response to several years of high incomes. Land prices in nominal terms rose by 234 percent, machinery purchases by 192 percent, and farm debt by 181 percent during 1972–79. Investors expected that the high cost of agriculture could be funded through continued stability or by increases in commodity prices. Compared with 1973–76, however, nominal corn, wheat, and soybean prices in 1987 where 20–40 percent lower. The price decline in real terms was approximately 60–70 percent, although the fall in prices was partly offset by increases in Government payments to farmers.

The effect of forecast error in the seventies and early eighties cannot be measured precisely. However, long-run financial consequences can be viewed in the light of agricultural loan writeoffs of approximatley $11 billion during 1984–86. They are estimated to reach $16–18 billion by the end of the eighties *(3)*.[1] Accumulated forecast errors in the past decade were characterized by higher than optimal investment, high borrowing rates, and high cost structure that contributed to record high expenditures for farm programs.

The beef sector in 1985 is a recent example of the adverse effects of forecast error. Because of weaker than anticipated prices in the first quarter, producers resorted to a longer feeding period, thereby increasing the weight equivalent to 897,000 slaughter steers and heifers during the first 9 months of 1985 (*13*, May 1985). The U.S. Department of Agriculture (USDA) outlook for Choice steer slaughter prices for the third quarter of 1985 ranged from $64–$68 per hundredweight (*13*, May 1985). The actual price of $58 per hundredweight *(11)* was about $6 less than initially projected for 1985. Given the inelastic demand for red meat, the lower price was directly related to the increased supply of heavyweight cattle. The production-related reduction in price of $6 per hundredweight affected the 21,457,000 steers and heifers slaughtered during the first 9 months of 1985. Thus, the expected loss (that is, the negative price reaction) associated with the decision to market heavyweight cattle may have been as much as $60 per head, or $1.3 billion. This estimate would increase to the extent that the value of the heavyweight gain was less than the cost of production specifically associated with that gain. The financial impact was recognizable almost immediately. Average cash income declined by $25,000, and debt increased by $16,000 for the typical commercial-sized beef producer with sales greater than $40,000 in 1985 *(16)*.

This illustration shows that, if resource demand is adjusted to respond to expectations that are not fully realized, output is likely to be suboptimal. The costs of expectational error are determined by the net differ-

Kolajo is a research associate and Martin is a professor in the Department of Agricultural Economics and Rural Sociology, Auburn University. Hanson is an agricultural economist with the Agriculture and Rural Economy Division, ERS.

[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

ence between optimal and realized incomes. Economists can use a farm-level evaluation of economic losses due to errors in forecasts in examining the value of information to decisionmaking.

Effect of Credit Constraints in Expectational Errors

External financing is typically required by commercial-sized producers. But interest expenses in agriculture increased from less than 5 percent of total cash expenses in 1957 to an estimated 15 percent in 1987. Interest expenses are now at the same level as the sum of important manufactured inputs, such as fertilizers, fuels and oils, electricity, and pesticides *(12)*. The rapid increase in the use of debt and the corresponding increase in the cost of servicing debt were associated with severe farm financial stress in the mideighties. Although financial stress stabilized or lessened in the Midwest and Northern Plains in 1986, financial conditions worsened in the Southeast and Delta States *(16)*.

Credit can be used to increase profits. However, if the rate of return on assets is less than the rate of interest on borrowed funds, the use of financial leverage tends to lower net income. As the ratios of debt to total assets increase, the difference between the rate of return on assets and the interest rate "magnifies" farm profits or losses. Thus, if price expectations are not realized, farm losses that are translated into additional indebtedness may eventually cause an operator to lose control of the farm. The risk of income shortfalls associated with financial decisions became more likely in the mideighties when prices of both commodities and long-term assets were declining.

Theoretical Considerations

As Shackle noted, "decision is choice, but not choice in face of perfect foreknowledge, not choice in face of complete ignorance. Decision, therefore, is choice in face of bounded uncertainty" (*9*, p. 5). Expectations are the foundation of economic decisions; that is, production and investment decisions derive from the decisionmaker's expectations of future outcomes.

The extent by which intended and executed plans deviate from actual outcomes may be expressed in terms of unanticipated net revenue gains or shortfalls. Unanticipated revenue shortfalls can be viewed as missed opportunities resulting from unrealized expenditures. Unanticipated revenue gains occur when expectations are exceeded. Although both revenue gains and shortfalls have opportunity costs, large shortfalls can threaten the financial survival of farm firms with high debt-to-asset ratios.

Larger than anticipated profits represent lost profit opportunities. This paradox can be explained as follows. If market prices exceed the expected price, the marginal physical product of fertilizer, for example, will exceed the ratio of input to output prices. Less than optimal use of inputs can lead to the loss of a firm's competitive edge, as fixed resources are gradually bid away by other firms that more nearly equate marginal factor cost (MFC) with marginal value product (MVP). Land prices, in particular, can be bid up rapidly by the more efficient firms during periods of farm profitability.

Unanticipated revenue shortfalls often cause borrowing to increase. The interest rate premium for loans (that is, above the interest rate on savings) increases the adverse consequences of shortfalls in income. Higher financing costs or a tightening of credit can increase cost structure. If asset restructuring (especially in the case of asset-downsizing) is required, loss of size economies could further reduce longrun competitiveness.

Denoting expectational error by L, we can express net revenue gain or shortfall in terms of output Y, realized or actual price per unit P, the amount of input x_i, and input price per unit w_i:

$$L = f(Y, P, x_i, w_i) \tag{1}$$

L can be represented in terms of net revenue changes induced by changes in input-output relations:

$$L = P\Delta Y - w_i \Delta x_i \tag{2}$$

where Δx_i and ΔY, respectively, denote changes in input and output levels induced by the decisionmakers' expectations of future outcomes. Equation 2 assumes a simplistic evaluation of L given that input and output change and that w_i and P are known. Although partly determined by P, L is not generally known during the planning period. The more relevant change-causing price may then be termed the planning price, P_e. Thus, one source of expectational error is the divergence between P and P_e.

For ease of exposition, assume one product, one variable input in combination with fixed inputs, and a given production function with fixed technology. Planned output fully adjusts to the planning price; that is, there is a corresponding quantity adjustment path to each planning price *(18)*. Figure 1 uses the concept of a production function to illustrate expectational error by distinguishing among consequent total value products (TVP). Actual TVP differs from the notional TVP (that is, total physical product multiplied by the planning price P). Figure 1 assumes that a change in output is motivated by a change in expected output price. A "negative" notional TVP (pessimistic price outlook) could be associated with reducing variable input costs (for exam-

ple, by reducing the number of sprayings for leaf spot in peanut production), whereas a "positive" notional TVP could increase input use (for example, spraying).

Expected prices exceeding actual prices reduce profits (triangle BCD in fig. 1). The optimistic, but unfulfilled, price expectation (P+) increased input use; thus, MFC exceeded MVP. However, anticipation of the low price (P−) and corresponding contraction of input use dropped MFC below MVP (P*). The triangle ABE represents the lost profit opportunity associated with pessimistic, but overfulfilled, price expectations.

Procedure

We estimated opportunity costs resulting from expectational errors from income streams based on (1) actual prices and yields and (2) expected prices and yields. The actual income streams were developed from the "historic" price and yield data of a typical crop farm in north Alabama over an 8-year period (1978–85). After scaling for the relative productivity of the typical farm, we assumed expected yields followed a 5-year moving average of the Colbert County yield data for 1973–85 *(1)*. Enterprise budgets were developed from the farm's production records. The formula for calculating the expected annual yield for each enterprise can be expressed as:

$$Y_t^* = \alpha\,(1/n \sum_{i=1}^{n} Y_{t-i})\quad t = 1, 2,\ldots, 8 \qquad (3)$$

where Y_t^* represents the expected annual yield per acre in year t, Y_t represents the actual yield per acre in t, n =5, and α is the scaled productivity adjustment factor. Year-to-year variability in actual yields exhibited greater dispersion than within-year differences between actual and expected yields *(7)*.

To reflect the effect of alternative price expectations on incomes, we assumed two expectational schemes: supply-based expectations (SBE) and adaptive expectations (ADE). We formulated the SBE by using the fundamental approach to price forecasting in commodity markets, which was based on the applied supply and demand paradigm *(2)*. We considered supply variables, such as intended plantings, harvested acres, yields, beginning stocks, and production level vis-a-vis demand variables, including domestic use of ouput, exports, ending stocks, and carryover of unused output, in estimating expected prices under the SBE scheme. This information is synthesized from USDA's annual estimates of aggregate crop production and use *(15)*.

The ADE approach is a variant of Nerlovian adaptive expectations. Expected net returns per acre in year t were expressed in terms of the expected yield per acre (Yt*), the actual price received in the previous year (Pt−1), and estimated production costs in the current year. Expectations based on returns per acre maximize the expected value of producer surplus *(5)*. The ADE scheme is a conservative approach to estimating planning prices. Although ADE may be conceived as a naive approach, because the search cost of information is minimized, it acknowledges learning from experience as superior. Table 1 shows actual and expected returns received and estimated.

The representative farm we analyzed produces cotton, soybeans, corn, and wheat. The farm operator was

Table 1—Net returns per acre under supply-based expectation (SBE) and adaptive expectation (ADE) schemes for modeled enterprises, 1978–85

Item	Cotton[1]			Soybeans			Corn			Wheat		
	Actual	SBE	ADE	Actual	SBE	ADE	Actual	SBE	ADE	Actual	SBE	ADE
	Dollars per acre											
1978	80.68	160.53	127.53	74.94	111.21	116.61	89.26	81.16	81.16	60.07	62.07	34.07
1979	149.47	182.37	221.37	217.98	108.02	111.92	135.39	82.89	90.09	182.61	84.07	73.57
1980	168.62	156.03	100.83	51.27	114.67	117.37	53.59	88.19	113.39	96.76	79.67	110.47
1981	280.73	131.55	128.75	117.86	130.67	103.07	197.93	116.87	158.87	97.30	97.15	61.55
1982	197.64	62.82	47.43	157.00	98.94	92.34	146.92	69.42	82.72	4.85	64.03	39.23
1983	176.76	152.06	10.46	116.12	68.68	54.64	201.85	61.45	51.85	94.30	78.98	35.32
1984	22.11	24.33	136.08	46.45	85.70	105.41	162.53	59.74	114.81	91.42	57.42	44.22
1985	284.84	225.78	91.53	41.74	77.58	94.38	173.06	49.74	59.34	27.38	83.42	68.22
Average	170.11	136.93	108.00	102.92	99.43	99.47	145.07	76.18	94.03	80.62	75.85	58.33
Standard deviation	89.87	64.71	63.20	62.04	20.81	20.37	51.67	21.05	34.44	55.81	13.48	26.02
	Percent											
C.V.[2]	52.83	47.25	58.52	60.28	20.93	20.48	35.62	27.63	36.63	69.23	17.77	44.61

[1] Expected net returns for cotton were generated under the assumptions that cottonseed yield was 1.6 times the pounds of lint and that seed prices were equivalent to the State's season-average prices. Gross income from cotton is thus an addition of incomes from both seed and lint.
[2] C.V. means coefficient of variation.

assumed to own 600 acres of land at the beginning of the planning period plus a sizeable complement of machinery, valued at $402,951.[2] The farm operator was assumed to have no initial outstanding debt. With no cash on hand at the beginning of the year, the farmer initiated the farming operation through financing. Average annual effective interest rates on current operating expenses were used for short-term loans *(18)*. We analyzed the trajectories of farm firm growth for low, medium, and high financial leverage. This procedure permitted alternative upper limits to debt financing of 25, 40, and 70 percent of the farm asset value. Survival was described as the ability to meet cash obligations without liquidating capital assets. The overall measure of a farm's well-being was indicated by its growth in net worth.

Given the assumption that any amount of land could be purchased at prevailing market prices, farm growth at the extensive margin was limited only by maximum feasible debt-to-asset ratio assumptions. We used historical land values per acre in Alabama *(14)* and effective annual interest rates on new farm loans provided by the Federal Land Bank of Jackson, MS, to determine land purchase and mortgage financing terms.

We applied two modeling approaches to this analysis, namely a conventional multiperiod linear programming (MPLP) model and a recursive strategic linear programming (RSLP) model. The conventional MPLP model derives optimal solutions over an entire planning period. The RSLP model is a sequential, optimizing procedure that incorporates the outcome from current-year decisions into the subsequent year's planning process. The models are distinguished by their treatment of information. In the MPLP framework a unitary elasticity of expectations is assumed, whereas in the RSLP model expectations are revised annually (as more information becomes available). We used the following procedure: (1) selected an optimization method, for example, MPLP; (2) ran the model with known net returns per acre; and (3) ran the model again with net returns estimates based on producer expectations, for example, SBE. Changes in profits (in effect, changes in net worth) could then be compared between the two model runs.[3] The analysis of managerial decisionmaking within a framework of alternative expectational schemes shows the importance of information processing.

Given the MPLP and RSLP optimization techniques and the alternative credit constraints discussed earlier, the implications of expectational (forecast) errors on farm firm decisions are analyzed below.

Annual Cost of Expectational Errors

A plausible way of quantifying expectational errors in monetary terms is to subtract the net revenue generated from a specified farm plan under a given expectational scheme from that of the optimum farm plan with known prices. The net revenue difference thus obtained represents the cost of expectational errors. A positive difference (that is, when the monetary outcome is larger than anticipated outcome) represents the cost of unrealized opportunities (area ABE in fig. 1). A negative difference (that is, the monetary outcome is less than anticipated) indicates a sustained loss (area BCD) in fig. 1). Marginal economic analysis would suggest that too few inputs were allocated in the former situation and too many inputs were allocated in the latter.

Tables 2 and 3 show revenue differences obtained under the SBE and ADE schemes with respect to both MPLP and RSLP models and alternative leverage conditions. In all situations analyzed, the extent of overshooting or undershooting realizable returns increased as the debt-to-asset ratio increased. Negative entries signify a shortage in cash-flow compared with the expected level. Several large negative entries would correspond to extreme cash-flow difficulties and possible farm failure. However, one can view the presence of (both) large positive and negative entries (tables 2 and 3) as constraining farm growth.

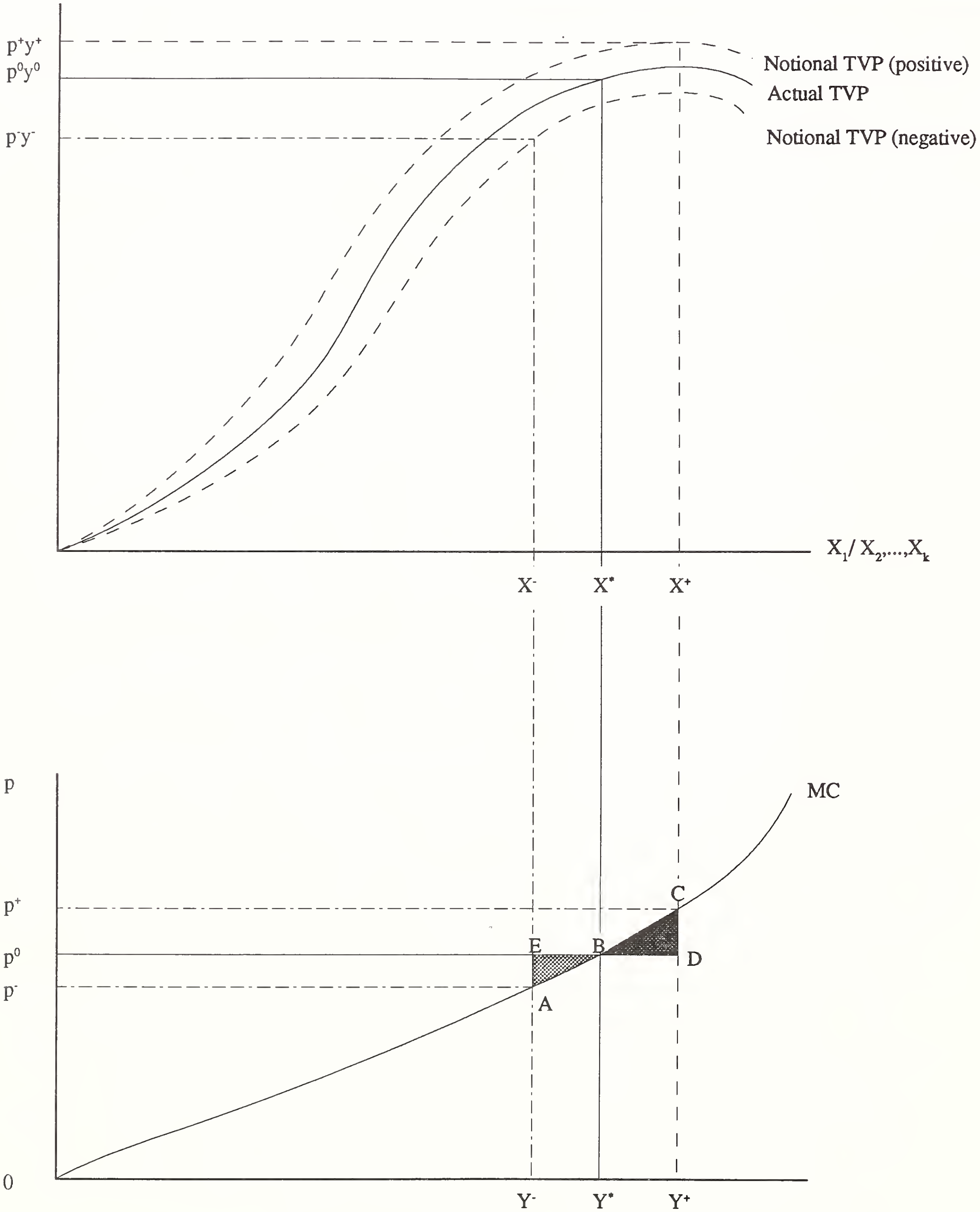
The MPLP model results generally indicated greater income shortfalls and gains than did the RSLP model results. In both approaches, the cost of errors increased as debt-to-asset ratios increased. Average shortfalls were greater in the ADE scheme. One cannot infer from the results that the cost of expectational errors increased or decreased over the years analyzed across financial leverages and modeling techniques. The size of average gains and shortfalls increased with the use of financial leverage, but the pattern was nonsystematic and nonproportional. However, enterprise organizations

[2]The farm's beginning assets included $316,200 in land and $86,751 in machinery, for a total *asset value* of $402,951. We assumed that the tractors and machinery could handle timely operations over a 5-year period. Specialized harvesting equipment could handle only 200 acres of cotton annually for 8 years and 400 acres of soybeans, corn, wheat, or a combination of the three (not exceeding 400 acres) in the first 5 years, while machinery capacity declined by 50 percent in subsequent years. For business accounting purposes, straight line depreciation was assumed. The accelerated cost recovery system applied to tax depreciation. Other tax features (prior to 1986) included the progressive income tax, the social security self-employment tax, the investment tax credit, the Alabama income tax, and the alternative minimum income tax. Consumption expense in the first year of the model was based on a minimum of $10,000 per year plus 25 percent of the aftertax expected annual income. This amount was adjusted by the average inflation rates for food and services *(17)*.

[3]Kolajo has discussed technical details concerning similarities and differences between the MPLP and RSLP models *(7)* that are beyond the scope of this article.

Figure 1

Effects of expectational errors in input use and profit potential



TVP = Total value product

The top chart indicates alternative total revenue functions resulting from different output price expectations.
The bottom chart shows the opportunity loss (triangle ABE) and sustained loss (triangle BCD) due to underutilization and overutilization of inputs, respectively.

Table 2—Expectational errors associated with supply-based expectations and alternative models and credit constraints, 1978-85[1]

Year	MPLP model results			RSLP model results		
	Low leverage	Medium leverage	High leverage	Low leverage	Medium leverage	High leverage
	Dollars[2]					
1978	-30,478	-30,478	-30,478	-47,910	-47,910	-47,910
1979	-21,680	56,181	71,010	-14,242	- 3,859	22,928
1980	-20,955	-40,018	-65,588	3,813	- 2,124	-13,991
1981	- 9,838	-12,400	-18,703	34,260	55,145	129,585
1982	44,590	56,202	84,768	38,552	45,809	75,652
1983	28,134	39,532	57,347	16,718	19,643	32,184
1984	-22,738	-30,588	-49,756	-26,062	-28,816	-51,143
1985	45,366	57,180	86,242	41,585	48,969	81,398
Average shortfall	-21,138	-28,371	-41,131	-29,405	-20,677	-37,681
Average gain	39,363	52,274	74,842	26,986	42,392	68,349

[1] Alternative models used are multiperiod linear programming (MPLP) and recursive strategic linear programming (RSLP), while credit constraints are represented by low, medium, and high leverage.

[2] Unanticipated gains and shortfalls are associated with positive and negative dollar amounts that indicate unrealized opportunities and sustained losses, respectively, resulting from price and yield forecasting errors of enterprise organizations. Researchers obtain both gains and shortfalls by subtracting realized net income from optimum net income, given the enterprise organizations chosen.

Table 3—Expectational errors associated with adaptive expectations and alternative models and credit constraints, 1978-85[1]

Year	MPLP model results			RSLP model results		
	Low leverage	Medium leverage	High leverage	Low leverage	Medium leverage	High leverage
	Dollars[2]					
1978	-25,002	-25,002	-25,002	-26,038	-26,038	-26,038
1979	71,486	58,801	83,938	17,403	-42,125	-79,378
1980	-51,029	-60,283	-81,832	-50,038	-57,705	-89,698
1981	30,154	35,623	48,356	29,998	34,099	53,004
1982	49,917	58,970	80,049	49,659	56,448	87,744
1983	43,097	50,844	71,378	28,773	36,642	64,984
1984	16,841	25,031	42,168	15,708	-21,238	2,990
1985	-23,175	-27,101	-46,229	-10,568	3,237	-71,432
Average shortfall	-33,069	-37,462	-51,021	-28,881	-36,777	-66,637
Average gain	42,299	45,854	65,178	28,308	32,607	52,181

[1] Alternative models used are multiperiod linear programming (MPLP) and recursive strategic linear programming (RSLP), while credit constraints are represented by low, medium, and high leverage.

[2] Unanticipated gains and shortfalls are associated with positive and negative dollar amounts that indicate unrealized opportunities and sustained losses resulting from price and yield forecasting errors of enterprise organizations. Researchers obtain both gains and shortfalls by subtracting realized net income from optimum net income, given the enterprise organizations chosen.

under the ADE scheme were more diversified than those under the SBE scheme.

Farm Growth Under SBE and ADE Schemes

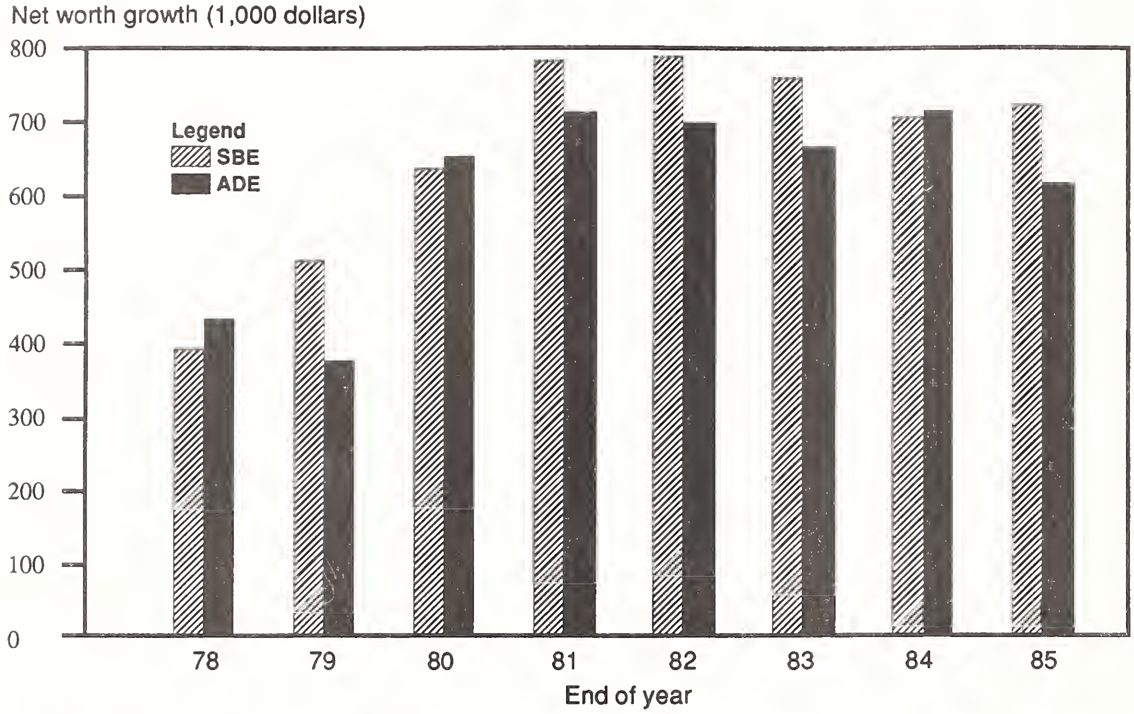
We analyzed farm growth, measured in terms of cumulative net worth, under the supply-based expectational (SBE) scheme and the adaptive expectational (ADE) scheme with respect to alternative leverage conditions. Figures 2 and 3 highlight the trajectories of farm growth described with the RSLP model.[4]

[4] Although the MPLP model indicates a faster rate of growth than the RSLP model, similar qualitative inferences can be drawn from both. In a quantitative sense, however, the results are different.

RSLP model results indicate that, as the farm business became increasingly leveraged, a disparity developed between the effects of SBE and ADE schemes on farm growth (figs. 2 and 3). Using the net worth criterion, we discovered that farm growth under the SBE scheme generally lagged behind the ADE scheme in the low-leverage situations. However, at the end of the planning period, the net worth of $672,788 in the SBE scheme exceeded that in the ADE scheme by more than $122,000. For most years, the SBE scheme generated higher net worth than the ADE scheme, particularly as the debt-to-asset ratio increased. The ending net worth with the SBE scheme in both medium- and high-leverage situations exceeded its ADE counterparts by more than $100,000. The disparity of these results indi-

Figure 2

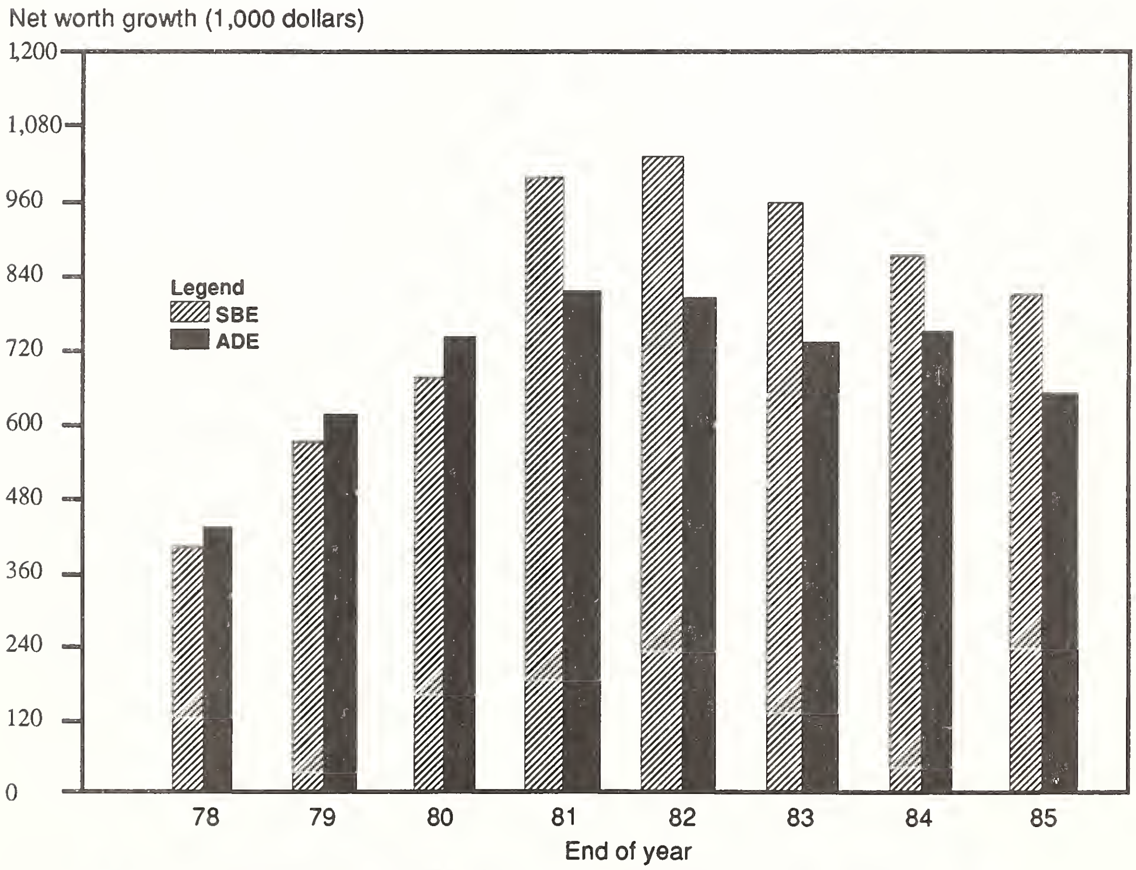
Net worth growth with medium leverage - RSLP model results



RLSP = Recursive strategic linear programming

Figure 3

Net worth growth with high leverage - RSLP model results



RLSP = Recursive strategic linear programming

cates the importance of the accuracy of economic forecasts. The growth paths of several farms with size and enterprise attributes similar to the model farm were more characteristic of the ADE scheme (*6*).

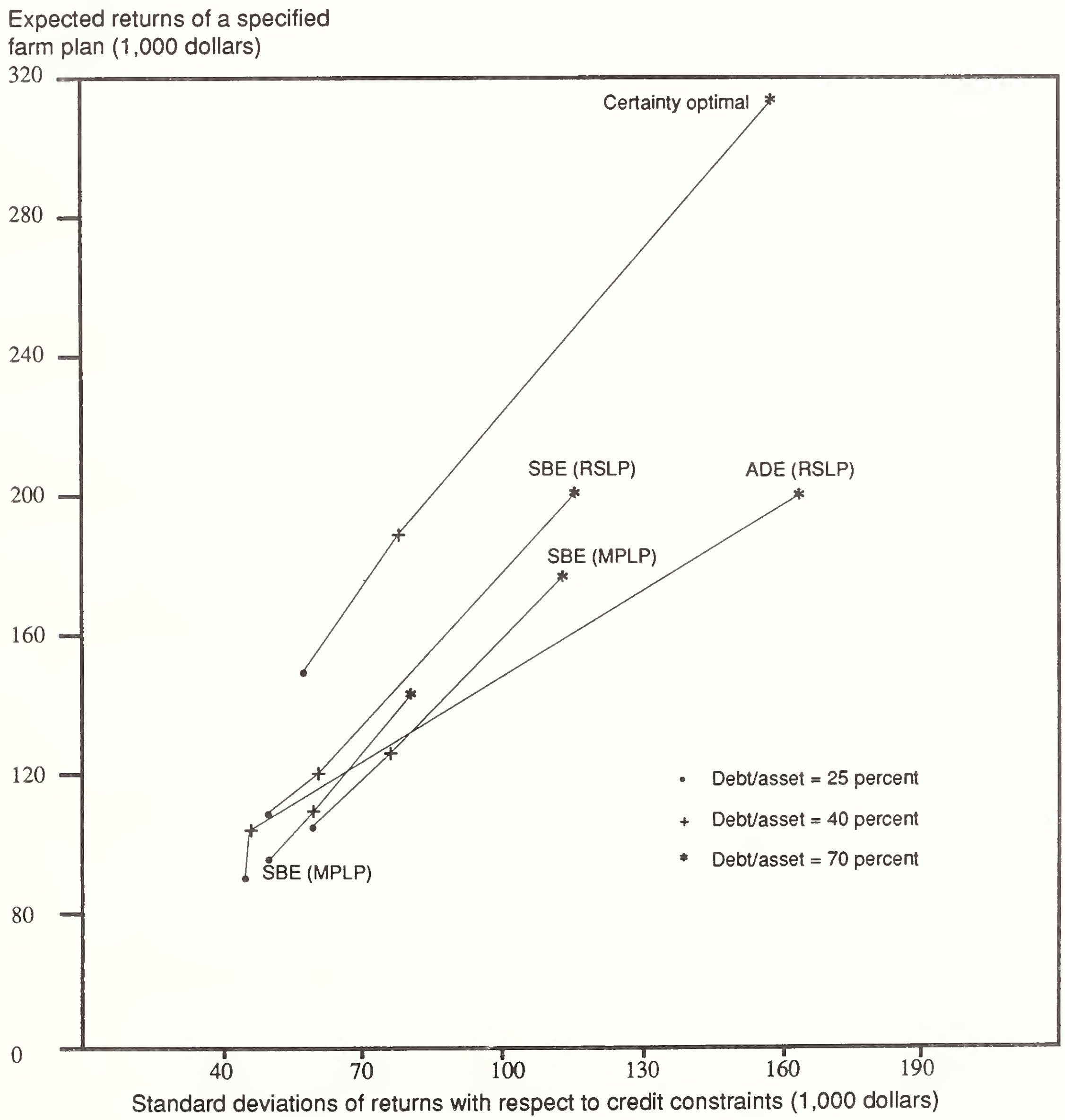
Analysis of Income Dispersions

Theoretically optimal plans were derived on an *ex post facto* basis from actual yields and prices received by the farmer. Using the theoretically optimal plans as the target, we can derive differences between "certainty incomes" and incomes obtained in the presence of expectational errors. The mean incomes derived for the optimal (certainty) plans, the SBE scheme, and the ADE scheme were plotted against the standard deviations of the annual returns. This exercise was conducted for each alternative credit constraint and modeling approach (fig. 4).

The certainty optimal plans have less risk for any mean than do the corresponding expectational schemes. The three points identified on each curve correspond with alternative debt-to-asset ratios. Each curve represents the locus of expected net returns and the associated standard deviations of such income with respect to debt-to-asset ratios. The certainty optimal plans conform to Tisdell's claim that, under perfect knowledge, price

Figure 4

Expected net returns and standard deviations with respect to alternative credit constraints



Note: Single-value expectations (certainty optimal), supply-based expectations (SBE), adaptive expectations (ADE), multiperiod linear programming (MPLP) model, and recursive strategic linear programming (RSLP) model.

instability (as exhibited by the variances of actual prices received (*7*) is often associated with greater expected returns than in the case of stable farm prices (*10*). Expected return-risk plans with the SBE scheme and the RSLP model approximated the certainty optimal plans better than the remaining combinations. With both models, the ADE scheme was associated with low-return/low-risk strategies. A disproportionate level of risk (compared with income) corresponded to the ADE (RSLP) scheme when the debt-to-asset ratio exceeded 40 percent. The MPLP model tended to underestimate the range of income variability relative to expected returns under alternative plans.

Implications

Substantial uncertainty about agricultural yields and prices often makes it difficult for farmers to formulate expectations. However, the nature of these expectations influences the size of the farm, the organization of the enterprises, the combination of resources employed, and the portfolio of assets held. Because expectations often deviate from realizations, farmers' decisions are inherently associated with errors.

Given the same initial assets and resources, our model results show that farm growth may follow divergent paths, depending both on the nature of a farmer's expectations and on the level of financial risk undertaken. When supply-based expectations (SBE) and adaptive expectations (ADE) were applied to production and price data of a crop farm in north Alabama, the cost of errors associated with SBE was lower. The SBE scheme also supported a faster rate of farm growth in most instances. Formulating production plans based on past prices and yields, however, was associated with risk-adverse behavior.

From a modeling perspective, the MPLP model generated a greater cost of expectational errors when evaluated in terms of unanticipated revenue gains and shortfalls. When the SBE scheme was assumed, unanticipated revenue gains for the MPLP model ranged from $39,363 to $74,842; for the RSLP model, gains ranged from $26,986 to $68,349. Under the SBE expectational scheme, unanticipated revenue shortfalls ranged from $21,138 to $41,131 with the MPLP model and ranged from $20,677 to $37,681 with the RSLP model. Under the ADE scheme, unanticipated gains ranged from $42,299 to $65,178 with the MPLP model and from $28,308 to $52,181 with the RSLP models. Unanticipated losses ranged from $33,069 to $51,021 with the MPLP model and from $28,881 to $66,637 with the RSLP model. Both unanticipated gains and losses increased disproportionately as debt-to-asset ratios increased.

As Havlicek and Seagraves (*4*) have noted, an analysis of costs associated with making the wrong decision provides a logical framework for assessing the benefits to research. Forecast errors can be transmitted from the researcher to the farmer by recommendations derived from a particular modeling technique. Thus, the choice of model and the assumptions incorporated into the model may constitute a source of errors. For example, generalizations of the results under the ADE scheme often suggest a pessimistic prospect. The MPLP model, as shown by the expected return vis-à-vis risk, may also understate the extent of income variability associated with increasing financial leverage. This situation is less likely with the RSLP model, which updates information over time. Thus, our main conclusion is methodological and may be useful to USDA's representative farm model research project and to similar modeling efforts in the land-grant universities.

We have shown the importance of information mangement in farm growth processes. We have demonstrated that the formation of expectations is a crucial element in micromodeling firm-level responses to technical and socioeconomic changes.

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Estimation of Transition Probabilities Using Median Absolute Deviations

C.S. Kim and Glenn Schaible

Abstract. *The probability-constrained minimum absolute deviations (MAD) estimator appears to be superior to the probability-constrained quadratic programming estimator in estimating transition probabilities with limited aggregate time series data. Furthermore, one can reduce the number of columns in the probability-constrained MAD simplex tableau by adopting the median property.*

Keywords. *Minimum absolute deviations, transition probabilities, median absolute deviations, quadratic programming.*

Markov processes are a special class of mathematical models that are often applied to economic decisionmaking in stochastic dynamic programming *(5)*, structural changes of an industry or changes in size economies *(23)*, or international trade *(6)*.[1] To estimate a meaningful transition matrix, researchers need time-ordered data that reflect intertemporal changes of micro units over states (or classifications). However, time-ordered changes of microeconomic units are generally not available for most economic variables; therefore, researchers must often work with aggregate time series data. In an ingenious article, Lee, Judge, and Takayama *(13)* showed how one can estimate transition probabilities for a Markov process reflecting the behavior of micro units with only aggregate time series data. They concluded from a limited trial, based on the assumption of normality of the error terms, that the probability-constrained quadratic programming (QP) estimator is superior to the probability-constrained minimum absolute deviations (MAD) estimator in estimating transition probabilities. In a subsequent article, Lee, Judge, and Zellner concluded from their sampling experiment that the probability-constrained MAD estimator is inferior to the probability-constrained QP estimator (*14*, p. 135).

We prove here that the probability-constrained MAD estimator is superior to the probability-constrained QP estimator when estimating transition probabilities with limited aggregate time series data. Second, we present an alternative model, minimization of median absolute deviations (MOMAD), based on the assumptions that the error terms are nonnormally distributed and that the researcher has *a priori* information about the dynamic nature of the Markov process. Third, we prove that the MOMAD estimator is identical with the probability-constrained MAD estimator, which Bassett and Koenker *(3)* concluded is a more efficient estimator for any error distribution for which the median is superior to the mean as an estimator of location. Moreover, the constraint matrix associated with the MOMAD model involves fewer columns in the simplex tableau.

Notation and Minimization of Absolute Deviations

The stochastic process of a finite Markov Chain can be expressed as:

$$\begin{aligned}\Pr(S_{it}, S_{j,t+1}) &= \Pr(S_{it}) \bullet \Pr(S_{j,t+1} \mid S_{it}, S_{i,t-1}, \ldots, S_{i0}) \\ &= \Pr(S_{it}) \bullet \Pr(S_{j,t+1} \mid S_{it}) \qquad (1)\\ &\text{(for all i and j)}\end{aligned}$$

where $\Pr(S_{it})$ represents the probability that state S_i occurs on trial t, $\Pr(S_{it}, S_{j,t+1})$ is the joint probability of S_{it} and $S_{j,t+1}$, and $\Pr(S_{j,t+1} \mid S_{it})$ represents the conditional probability for the state S_j. Equation 1, presented by Kemeny and Snell *(12)*, explains that the probability of going to each of the states depends only on the present state and is independent of how we arrived at that state.

Summing both sides of equation 1 over all possible outcomes of the state S_i may be represented by:

$$\begin{aligned}\Pr(S_{j,t+1}) &= \sum_{i}^{r} \Pr(S_{it}) \bullet \Pr(S_{j,t+1} \mid S_{it}) \qquad (2)\\ &= \sum_{i}^{r} \Pr(S_{it}) \bullet P_{ij}\end{aligned}$$

Kim and Schaible are economists with the Commodity Economics Division and the Resources and Technology Division, ERS. They appreciate the helpful comments of V.A. Sposito at Iowa State University, T.C. Lee at the University of Connecticut, and G.G. Judge at the University of California-Berkeley on an earlier draft of this paper.

[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

where P_{ij} represents the transition probability and has the following properties:

$$P_{ij} \geq 0 \quad \text{for all i and j} \tag{3}$$

$$\sum_{j} P_{ij} = 1 \tag{4}$$

By replacing $Pr(S_{j,t+1})$ and $Pr(S_{it})$ with the observed proportions y_{jt} and $x_{i,t-1}$, respectively, we can write equation 2 in the following conventional notation for regression analysis:

$$y_{jt} = \sum_{i}^{r} X_{i,t-1} \bullet P_{ij} + \epsilon_{jt} \; (j = 1, 2,..., r) \tag{5}$$

where y_{jt} reflects the observed proportion in state j in time t, $X_{i,t-1}$ is the observed value of the proportion in state i in time t–1, and ϵ represents a random disturbance.

In estimating models of the type described in equation 5, researchers have made extensive use of the methods of minimizing the sum of absolute and/or squared errors. Although the method of least squares is superior to the MAD procedure if the random events being considered are normally distributed, Bassett and Koenker *(3)* and Hill and Holland *(9)* demonstrate that the MAD estimator is a superior robust method, especially for nonnormal error distributions. Bassett and Koenker show that, for any error distribution for which the median is superior to the mean as an estimator of location, the MAD estimator is preferable to the least squares estimator, in the sense of having strictly smaller asymptotic confidence regions. Bassett and Koenker note that this condition holds for an enormous class of distributions that either have peaked density at the median or have long tails.

The observed proportions for each time period in equation 5 are multinomially distributed, and the multinomial reduces to the binomial when the individual is considered either to be or not to be in state i. The binomial probabilities increase monotonically until they reach a maximum value and then decrease monotonically. One can show whether or not the binomial is symmetrically distributed by proving that $\alpha_3 = U_3/\sigma^3$ equals zero where U_3 is the third moment about the mean of the binomial distribution. For the binomial distribution, with the probability θ of being in state i, the components of α_3 can be derived as $U_3 = n\theta(1-\theta)(1-2\theta)$ and $\sigma^3 = [n\theta(1-\theta)]^{3/2}$, where n is the sample size. Therefore, for the binomial distribution, the measure of skewness can be written as:

$$\alpha_3 = \frac{U_3}{\sigma^3} = \frac{1 - 2\theta}{[n\theta(1-\theta)]^{1/2}} \tag{6}$$

From equation 6, the binomial is symmetric if $\theta = 1/2$ and/or the sample size n becomes exceedingly large. Because aggregate time series data are used to estimate transition probabilities, it is reasonable to assume that the sample size is not large. When there are more than two states, so that the probability of the individual being in state i cannot be 0.5 for each state because of constraint 4, the binomial is asymmetrically distributed and the probability-constrained MAD estimator would be superior to the probability-constrained QP estimator.

Consider the problem of estimating an r^2 dimensional vector of unknown parameters P_{ij} from a sample of independently observed proportions for each time period on the random variables $Y_{11},..., Y_{rT}$ with the following probability distribution:

$$Pr[Y_{jt} < y_{jt}] = F(y_{jt} - \sum_{i=1}^{r} X_{i,t-1} \bullet P_{ij}) \tag{7}$$

where j = 1, 2,..., r; and t = 1, 2,..., T.

The probability-constrained MAD estimator $\tilde{P}$ is a solution to the following problem:

$$\underset{P \in R^{rxr}}{\text{Minimize}} \; [\sum_{j=1}^{r} \sum_{t=1}^{T} | \, y_{jt} - \sum_{i=1}^{r} X_{i,t-1} \bullet P_{ij} \, | \,] \tag{8}$$

Following Barrodale and Young *(2)*, Lee and others *(14)*, Sposito *(20)*, *(21)*, and Spyropoulos and others *(22)*, the probability-constrained MAD estimator is then a solution to the problem:

$$\text{Minimize} \sum_{j=1}^{r} \sum_{t=1}^{T} (U_{jt} + V_{jt}) \tag{9}$$

$$\text{subject to:} \sum_{j}^{r} P_{ij} = 1.0 \text{ for } i = 1, 2,..., r \tag{10}$$

$$\sum_{i}^{r} X_{i,t-1} \bullet P_{ij} - U_{jt} + V_{jt} = y_{jt} \tag{11}$$

for j = 1, 2,..., r; t = 1, 2,..., T

$$U_{jt}, V_{jt}, \text{ and } P_{ij} \geq 0 \tag{12}$$

for all i, j, and t

Minimization of Median Absolute Deviations

Since Hazell *(8)* introduced the minimization of total absolute deviations (MOTAD) model, several economists have identified the MAD criterion as "minimizing the mean absolute deviations" (see *4, 10, 11, 24*). However, the median property has not received sufficient attention among economists. A number of authors have discussed the concept of the median property. Andrews *(1)*, Bassett and Koenker *(3)*, Harvey *(7)*, and Hill and Holland *(9)* showed that the minimum absolute deviations estimator is superior to the least-squares estimator, when the median is superior to the mean as an estimator of location for nonnormal distributions. Furthermore, Spyropoulos and others *(22)* showed that a median property can be used to improve the rate of convergence of linear programming solutions associated with minimum absolute deviations (see *(16)* for the case of nonconvergence). Finally, Parzen *(18)* and Sposito *(21)* show that, for a random variable e, the quantity $\sum_i |e_i - c|$ achieves its minimum value when c is equal to the median.

Following Bassett and Koenker *(3)*, we assume that P_{ij} for all i and j are located so that the probability distribution function F in equation 7 has median zero. Because the median is the point that divides the area under the probability density function, we have the following equality:

$$\Pr\left(\sum_i^r X_{i,t-1} \bullet P_{ij} > y_{jt}\right) = \Pr\left(\sum_i^r X_{i,t-1} \bullet P_{ij} < y_{jt}\right) = 1/2 \qquad (13)$$

In several situations, researchers have *a priori* knowledge about the dynamic nature of transition probabilities. As energy costs have risen and irrigation water has become more scarce, for example, irrigation technology adopted by farmers has changed from high-pressure, water-intensive systems to low-pressure, energy- and water-efficient systems. Recent irrigation technology shifts in the Southern High Plains have involved a transition from high-pressure center-pivot systems to low-energy precision application (LEPA) systems, whereas Southwest irrigation of tree crops has been shifting from gravity-fed to drip irrigation systems. The proportion of energy- and water-efficient irrigation systems has been increasing, suggesting positive median deviations. As an example suggesting negative deviations over time, we have observed that the number of smokers among professionals has decreased, and that this trend is likely to continue.

In these cases, researchers may be interested in the positive or negative median deviations in equation 13, depending on whether the dynamic nature of transition probabilities moves toward positive or negative deviations. These cases suggest an alternative specification for the probability-constrained MAD model based on minimizing only the sum of the absolute values of the negative median deviations or the sum of the absolute values of the positive median deviations. We can minimize the sum of the absolute values of the negative median deviations by solving the following linear programming model:

Model I

$$\text{Minimize} \quad \sum_{j=1}^{r} \sum_{t=1}^{T} Z_{jt}^{-} \qquad (14)$$

$$\text{subject to:} \quad \sum_j^r P_{ij} = 1.0 \text{ for } i = 1, 2, \ldots, r \qquad (15)$$

$$\sum_i^r X_{i,t-1} \bullet P_{ij} + Z_{jt}^{-} \geq y_{jt} \qquad (16)$$

$$\text{for } j = 1, 2, \ldots, r;\ t = 1, 2, \ldots, T \text{ and } Z_{jt}^{-}, \text{ and } P_{ij} \geq 0 \qquad (17)$$

where $\sum_{j=1}^{r} \sum_{t=1}^{T} Z_{jt}^{-}$ is the sum of the absolute values of the negative median deviations.

An alternative model can be specified that minimizes only the sum of the absolute values of the positive median deviations as follows:

Model II

$$\text{Minimize} \quad \sum_{j=1}^{r} \sum_{t=1}^{T} Z_{jt}^{+} \qquad (18)$$

$$\text{subject to:} \quad \sum_j^r P_{ij} = 1.0 \text{ for } i = 1, 2, \ldots, r \qquad (19)$$

$$\sum_i^r X_{i,t-1} \bullet P_{ij} - Z_{jt}^{+} \leq y_{jt} \qquad (20)$$

$$\text{for } j = 1, 2, \ldots, r;\ t = 1, 2, \ldots, T \text{ and } Z_{jt}^{+}, \text{ and } P_{ij} \geq 0 \qquad (21)$$

where $\sum_{j=1}^{r} \sum_{t=1}^{T} Z_{jt}^{+}$ is the sum of the absolute values of the positive median deviations.

For any error distribution for which the median is superior to the mean as an estimator of location, the MOMAD estimator for both model I and model II is identical with the probability-constrained MAD estimator. We can easily prove the identity by first converting equations 9 through 12 into matrix notation as follows:

$$\text{Minimize} \quad (U + V)' e_{rT} \tag{9'}$$

$$\text{subject to:} \quad GP = e_r \tag{10'}$$

$$XP - U + V = Y \tag{11'}$$

$$P, U, V \geq 0 \tag{12'}$$

where U and V are $(rT \times 1)$ column vectors of surplus and slack variables, respectively; e_{rT} is an $(rT \times 1)$ column vector with all elements 1; X is an $(rT \times r^2)$ block diagonal matrix; P is an $(r^2 \times 1)$ column vector; Y is an $(rT \times 1)$ column vector; and G is an $(r \times r^2)$ coefficient matrix, such that $G = [I_1, I_2, \ldots, I_r]$ with each I_i an $(r \times r)$ identity matrix. Now define variable Z as follows:

$$Z = (U + V) \tag{22}$$

where Z is an $(rT \times 1)$ column vector.

Rearranging equation 22, we have the equation:

$$V = Z - U \tag{23}$$

or equivalently:

$$U = Z - V \tag{24}$$

Inserting equations 22 and 23 into equations 9′ and 11′, respectively, the probability-constrained MAD model can be rewritten as follows:

$$\text{Minimize} \quad Z' e_{rT} \tag{25}$$

$$\text{subject to:} \quad GP = e_r \tag{26}$$

$$XP + Z - 2U = Y \tag{27}$$

$$P, Z, U \geq 0 \tag{28}$$

or equivalently as:

MOMAD Model I

$$\text{Minimize} \quad Z' e_{rT} \tag{29}$$

$$\text{subject to:} \quad GP = e_r \tag{30}$$

$$XP + Z \geq Y \tag{31}$$

$$P, Z \geq 0 \tag{32}$$

which is identical with the MOMAD Model I given in equations 14 through 17, where $Z = Z^-$

In cases where equations 22 and 24 are inserted into equations 9′ and 11′, respectively, the probability-constrained MAD model can be rewritten as follows.

$$\text{Minimize} \quad Z' e_{rT} \tag{33}$$

$$\text{subject to:} \quad GP = e_r \tag{34}$$

$$XP - Z + 2V = Y \tag{35}$$

$$P, Z, V \geq 0 \tag{36}$$

or equivalently as:

MOMAD Model II

$$\text{Minimize} \quad Z' e_{rT} \tag{37}$$

$$\text{subject to:} \quad GP = e_r \tag{38}$$

$$XP - Z \leq Y \tag{39}$$

$$P, Z, \geq 0 \tag{40}$$

which is identical with the MOMAD model II given in equations 18 through 21, where $Z = Z^+$.

Consequently, the probability-constrained MAD estimators are identical with the probability-constrained MOMAD estimators. However, the MOMAD procedure reduces rT variables from the probability-constrained MAD procedure to estimate the transition probabilities of the finite Markov Process.

Properties of the MOMAD Estimator

Properties of the QP and MAD estimators associated with the probability constraints in equation 10 are unknown. Therefore, we restrict our discussion to the QP and MAD estimators without the probability constraints. Since the MOMAD estimator is conceptually identical with the probability-constrained MAD estimator when the median is superior to the mean as an estimator of location, we shall concentrate our discussion on the properties of the MAD estimator only.

Let m represent the population median. For a continuous random variable e, the sample median is asymptotically normal with mean m and variance $[4rTf^2(m)]^{-1}$, where $f(\bullet)$ is the population density function. Under the assumption that P_{ij} is located so that the distribution function F in equation 7 has median zero, $\sqrt{rT}(\tilde{P} - P)$ converges in distribution to an r^2 dimensional Gaussian random vector with mean zero and covariance matrix $W^2 \bullet Q^{-1}$ *(3)*. Here $\tilde{P}$ is a vector of the MAD estimator $\tilde{P}_{ij}$, P is a vector of the parameter

P_{ij}, $W^2 = [4f^2(O)]^{-1}$, and $Q = \lim (rT)^{-1}X'_{rT}X_{rT}$. In other words, the MAD estimator is consistent as well as asymptotically Gaussian for a large sample, with a covariance matrix $[W^2 \bullet Q^{-1}]$. Thus, the MAD estimator has strictly smaller asymptotic confidence regions than the QP estimator for linear models from any distribution function F for which the sample median is a more efficient estimator of location than the sample mean.

A Numerical Example

To illustrate the MOMAD procedure as well as to demonstrate that the MAD estimator is superior to the QP estimator, we use the numerical example used by Lee, Judge, and Takayama *(13)*. In matrix notation form, the transition probabilities to be estimated are as follows:

$$P = \begin{array}{c} \\ S_1 \\ S_2 \\ S_3 \\ S_4 \end{array} \begin{array}{c} \begin{array}{cccc} S_1 & S_2 & S_3 & S_4 \end{array} \\ \begin{bmatrix} 0.6 & 0.4 & 0 & 0 \\ 0.1 & 0.5 & 0.4 & 0 \\ 0 & 0.1 & 0.7 & 0.2 \\ 0 & 0 & 0.1 & 0.9 \end{bmatrix} \end{array} \qquad (41)$$

Table 1 shows the synthetic data relating to the sample proportions in each state. As Lee, Judge, and Takayama experimented, we assumed that we do not know the transition probability matrix (equation 41), but have only the information contained in the aggregate data in table 1. Under this assumption, we estimate the transition probabilities by the probability-constrained QP, MAD, and MOMAD procedures (tables 2 and 3). Table 2 con-

Table 1—Synthetic data relating to the sample proportions in each state

Time period	Proportion in state (i)			
	S_1	S_2	S_3	S_4
8	0.0815	0.1890	0.3999	0.3296
9	.0678	.1671	.3885	.3766
10	.0574	.1495	.3765	.4166
11	.0494	.1354	.3650	.4502
12	.0431	.1239	.3546	.4784
13	.0383	.1147	.3457	.5013
14	.0345	.1072	.3380	.5203
15	.0314	.1012	.3315	.5359
16	.0290	.0963	.3261	.5486
17	.0270	.0924	.3216	.5590
18	.0254	.0892	.3180	.5674

Table 2—The probability-constrained QP, MAD, and MOMAD estimates of the transition matrix from different ascending portions of the aggregate data for a Markov process

Time period	Estimators		
	QP	MAD	MOMAD[1]
t = 8,9,...,18	$\begin{bmatrix} 0.753 & 0.237 & 0 & 0.010 \\ 0 & .624 & .376 & 0 \\ .016 & .071 & .716 & .197 \\ 0 & .004 & .095 & .901 \end{bmatrix}$	$\begin{bmatrix} 0.598 & 0.402 & 0 & 0 \\ .101 & .508 & .391 & 0 \\ 0 & .094 & .706 & .200 \\ 0 & .002 & .098 & .900 \end{bmatrix}$	$\begin{bmatrix} 0.598 & 0.402 & 0 & 0 \\ .101 & .508 & .391 & 0 \\ 0 & .094 & .706 & .200 \\ 0 & .002 & .098 & .900 \end{bmatrix}$
t = 9,10,...,18	$\begin{bmatrix} .755 & .245 & 0 & 0 \\ 0 & .595 & .405 & 0 \\ .016 & .086 & .699 & .199 \\ 0 & 0 & .099 & .901 \end{bmatrix}$	$\begin{bmatrix} .597 & .403 & 0 & 0 \\ .101 & .509 & .390 & 0 \\ 0 & .093 & .707 & .200 \\ 0 & .002 & .098 & .900 \end{bmatrix}$	$\begin{bmatrix} .597 & .403 & 0 & 0 \\ .101 & .509 & .390 & 0 \\ 0 & .093 & .707 & .200 \\ 0 & .002 & .098 & .900 \end{bmatrix}$
t = 10,11,...,18	$\begin{bmatrix} .754 & .246 & 0 & 0 \\ 0 & .589 & .411 & 0 \\ .016 & .088 & .698 & .198 \\ 0 & 0 & .099 & .901 \end{bmatrix}$	$\begin{bmatrix} 0.608 & .392 & 0 & 0 \\ .097 & .524 & .379 & 0 \\ 0 & .089 & .712 & .199 \\ 0 & .004 & .096 & .900 \end{bmatrix}$	$\begin{bmatrix} .608 & .392 & 0 & 0 \\ .097 & .524 & .379 & 0 \\ 0 & .089 & .712 & .199 \\ 0 & .004 & .096 & .900 \end{bmatrix}$
t = 11,12,...,18	$\begin{bmatrix} .749 & 0 & .251 & 0 \\ 0 & .728 & .272 & 0 \\ .017 & .068 & .718 & .197 \\ 0 & 0 & .098 & .902 \end{bmatrix}$	$\begin{bmatrix} .765 & .235 & 0 & 0 \\ 0 & .596 & .404 & 0 \\ .015 & .086 & .699 & .200 \\ 0 & 0 & .100 & .900 \end{bmatrix}$	$\begin{bmatrix} .765 & .235 & 0 & 0 \\ 0 & .596 & .404 & 0 \\ .015 & .086 & .699 & .200 \\ 0 & 0 & .100 & .900 \end{bmatrix}$
t = 12,13,...,18	$\begin{bmatrix} .856 & 0 & 0 & .144 \\ 0 & .758 & .242 & 0 \\ 0 & .059 & .776 & .165 \\ .004 & 0 & .083 & .913 \end{bmatrix}$	$\begin{bmatrix} .687 & 0 & .313 & 0 \\ .057 & .736 & .207 & 0 \\ .005 & .066 & .729 & .200 \\ 0 & 0 & .100 & .900 \end{bmatrix}$	$\begin{bmatrix} 0.687 & 0 & .313 & 0 \\ .057 & .736 & .207 & 0 \\ .005 & .066 & .729 & .200 \\ 0 & 0 & .100 & .900 \end{bmatrix}$
t = 13,14,...,18	$\begin{bmatrix} .824 & 0 & 0 & 0.176 \\ 0 & .856 & 0 & .144 \\ 0 & 0 & .923 & .077 \\ .006 & .018 & .038 & .938 \end{bmatrix}$	$\begin{bmatrix} .608 & 0.228 & .164 & 0 \\ .097 & .600 & .303 & 0 \\ 0 & .086 & .713 & .201 \\ 0 & 0 & .101 & .899 \end{bmatrix}$	$\begin{bmatrix} .608 & .228 & .164 & 0 \\ .097 & .600 & .303 & 0 \\ 0 & .086 & .713 & .201 \\ 0 & 0 & .101 & .899 \end{bmatrix}$

[1] Estimators for MOMAD models I and II.

Table 3—The probability-constrained QP, MAD, and MOMAD estimates of the transition matrix from different descending portions of the aggregate data for a Markov process

Time period	Estimators		
	QP	MAD	MOMAD[1]
t = 8,9,...,17	$\begin{bmatrix} 0.752 & 0.248 & 0 & 0 \\ 0 & .615 & .371 & .014 \\ .016 & .073 & .720 & .191 \\ 0 & .004 & .093 & .903 \end{bmatrix}$	$\begin{bmatrix} 0.600 & 0.400 & 0 & 0 \\ .100 & .503 & .390 & .007 \\ 0 & .098 & .706 & .196 \\ 0 & 0 & .098 & .902 \end{bmatrix}$	$\begin{bmatrix} 0.599 & 0.401 & 0 & 0 \\ .101 & .504 & .388 & .007 \\ 0 & .097 & .707 & .196 \\ 0 & 0 & .098 & .902 \end{bmatrix}$
t = 8,9,...,16	$\begin{bmatrix} .750 & .250 & 0 & 0 \\ 0 & .612 & .371 & .017 \\ .017 & .075 & .719 & .189 \\ 0 & .003 & .093 & .904 \end{bmatrix}$	$\begin{bmatrix} .613 & .387 & 0 & 0 \\ .091 & .516 & .388 & .005 \\ .002 & .094 & .708 & .196 \\ 0 & .001 & .097 & .902 \end{bmatrix}$	$\begin{bmatrix} .613 & .387 & 0 & 0 \\ .091 & .516 & .388 & .005 \\ .002 & .094 & .708 & .196 \\ 0 & .001 & .097 & .902 \end{bmatrix}$
t = 8,9,...,15	$\begin{bmatrix} .749 & .228 & 0 & .023 \\ 0 & .631 & .369 & 0 \\ .017 & .070 & .721 & .192 \\ 0 & .004 & .093 & .903 \end{bmatrix}$	$\begin{bmatrix} .599 & .401 & 0 & 0 \\ .101 & .503 & .388 & .008 \\ 0 & .098 & .707 & .195 \\ 0 & .001 & .097 & .902 \end{bmatrix}$	$\begin{bmatrix} .598 & .402 & 0 & 0 \\ .101 & .502 & .389 & .008 \\ 0 & .098 & .707 & .195 \\ 0 & 0 & .098 & .902 \end{bmatrix}$
t = 8,9,...,14	$\begin{bmatrix} .746 & .216 & 0 & .038 \\ 0 & .631 & .369 & 0 \\ .017 & .074 & .721 & .188 \\ 0 & .002 & .093 & .905 \end{bmatrix}$	$\begin{bmatrix} .699 & .301 & 0 & 0 \\ .032 & .574 & .389 & .005 \\ .012 & .085 & .707 & .196 \\ 0 & .001 & .098 & .901 \end{bmatrix}$	$\begin{bmatrix} .699 & .301 & 0 & 0 \\ .032 & .574 & .389 & .005 \\ .012 & .085 & .707 & .196 \\ 0 & .001 & .098 & .901 \end{bmatrix}$
t = 8,9,...,13	$\begin{bmatrix} .772 & .228 & 0 & 0 \\ 0 & .632 & .368 & 0 \\ .008 & .069 & .722 & .201 \\ .005 & .004 & .092 & .899 \end{bmatrix}$	$\begin{bmatrix} .756 & .243 & .001 & 0 \\ 0 & .608 & .385 & .007 \\ .014 & .080 & .710 & .196 \\ .001 & 0 & .097 & .902 \end{bmatrix}$	$\begin{bmatrix} .756 & .243 & .001 & 0 \\ 0 & .608 & .385 & .007 \\ .014 & .080 & .710 & .196 \\ .001 & 0 & .097 & .902 \end{bmatrix}$
t = 8,9,...,12	$\begin{bmatrix} .767 & 0 & .233 & 0 \\ 0 & .784 & .216 & 0 \\ .014 & .047 & .735 & .204 \\ 0 & 0 & .104 & .896 \end{bmatrix}$	$\begin{bmatrix} .598 & .396 & .006 & 0 \\ .101 & .505 & .380 & .014 \\ 0 & .099 & .711 & .190 \\ 0 & 0 & .096 & .904 \end{bmatrix}$	$\begin{bmatrix} .598 & .396 & .006 & 0 \\ .101 & .505 & .380 & .014 \\ 0 & .099 & .711 & .190 \\ 0 & 0 & .096 & .904 \end{bmatrix}$

[1] Estimators for MOMAD models I and II.

tains the estimators of the transition matrix from different ascending portions of the aggregate data, while table 3 used different descending portions of the aggregate data. The probability-constrained QP estimator, using the trials (t = 8, 9,.., 18) in table 2, differs from that presented by Lee, Judge, and Takayama *(13)*. Similarly, the probability-constrained QP estimator for the trials (t = 8, 9,.., 12) in table 3 differs from that presented by Lee, Judge, and Zellner *(14)*. These authors used a simplex algorithm developed by Wolfe *(25)*, whereas we used Minos, developed by Murtagh and Saunders *(17)*, which uses the reduced-gradient algorithm, also developed by Wolfe *(26)*.

Tables 2 and 3 show that the probability-constrained MAD and MOMAD estimators are identical. Furthermore, the MOMAD estimator is more efficient than the probability-constrained QP estimator. However, the efficiency between these two estimators needs further study.

Comparison of the QP and MOMAD Estimators

The sample median is asymptotically normal with mean (m) and variance $[4rTf^2(m)]^{-1}$, where (m) is the population median and f(•) is the population probability density function. Because the probability density function f(m) is unknown, there are no meaningful statistical test procedures based on the sample median. Therefore, a nonparametric statistical method (the binomial test) is used to check the significance of the differences in the dispersion of the estimators about the true parameters *(14)*.

The null hypothesis to be tested is as follows:

$$H_0: \Pr[\,|\,\tilde{\tilde{P}}_{ij} - P_{ij}\,| > |\,\hat{P}_{ij} - P_{ij}\,|\,] = 1/2$$

relative to the alternative:

$$H_A: \Pr[\,|\,\tilde{\tilde{P}}_{ij} - P_{ij}\,| > |\,\hat{P}_{ij} - P_{ij}\,|\,] > 1/2$$

where $\tilde{\tilde{P}}_{ij}$, $\hat{P}_{ij}$, and P_{ij} are the probability-constrained QP estimator, the MOMAD estimator, and the true parameter, respectively.

The procedures of the binomial test and its statistical table can be found in Siegel *(19)*. We applied the test using only those pairs in which there is no tie (see *15*). The results of the binomial test show that the MOMAD estimator is at least as efficient as, or more efficient than, the probability-constrained QP estimator in estimating the transition probabilities (table 4).

Table 4—The binomial tests for H_0:
$\Pr[\,|\,\tilde{\tilde{P}}_{ij} - P_{ij}\,| > |\,\hat{P}_{ij} - P_{ij}\,|\,] = 1/2$
vs.
$H_A: \Pr[\,|\,\tilde{\tilde{P}}_{ij} - P_{ij}\,| > |\,\hat{P}_{ij} - P_{ij}\,|\,] > 1/2$

Time period	Probabilities associated with values in the binomial test	Superior estimator based on the binomial test at $\alpha = 0.05$
t = 8, 9,..., 18	0	MOMAD
t = 9, 10,..., 18	.194	QP and MOMAD
t = 10, 11,..., 18	.275	QP and MOMAD
t = 11, 12,..., 18	.006	MOMAD
t = 12, 13,..., 18	.046	MOMAD
t = 13, 14,..., 18	0	MOMAD
t = 8, 9,..., 17	0	MOMAD
t = 8, 9,..., 16	0	MOMAD
t = 8, 9,..., 15	.001	MOMAD
t = 8, 9,..., 14	.001	MOMAD
t = 8, 9,..., 13	.212	QP and MOMAD
t = 8, 9,..., 12	.033	MOMAD

Conclusions

We have proposed the use of the minimization of median absolute deviations (MOMAD) to estimate transition probabilities of a finite Markov chain with limited aggregate time series data. The MOMAD model is conceptually identical with the MAD model. However, the MOMAD model is simpler to use than the probability-constrained MAD procedure, while using a linear programming algorithm. We also showed that the MOMAD estimators are more efficient than the QP estimators by demonstrating that: (1) the MOMAD and MAD models are conceptually identical, and (2) the MAD estimators and, therefore, the MOMAD estimators are more efficient than the QP estimators.

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Stationarity Assumptions and Technical Change in Supply Response Analysis

John W. McClelland and Harry Vroomen

Abstract. *Proper stationarity assumptions (trend stationarity or difference stationarity) are important for modeling agricultural supply response in the context of time series analysis. Test results show that the assumption of trend stationarity should be a tested rather than a maintained hypothesis. We discuss implications of model misspecification in the interpretation of trend line regression coefficients as a proxy for technical change. The analysis suggests a more careful consideration of stationarity assumptions when this method is employed in the future.*

Keywords. *Stationarity, time series, supply response.*

Analysts of supply response for major agricultural commodities often rely on time series data to estimate behavioral relationships econometrically. Forecast results are important to policymakers who must decide the direction of U.S. agricultural policy.

Researchers commonly decompose real variables, such as output or acres planted, into a growth component and a cyclical component. The growth component results from changes in factors such as capital stock, population, or technology, whereas the stationary cyclical component is the result of monetary or price factors. The econometric procedure relied on for the decomposition into growth and cyclical factors is often a regression with time as an independent variable. Residuals resulting from this detrending procedure are then treated as a stationary series.

Several papers have appeared in the economics literature discussing the problem of inappropriately detrending macroeconomic time series *(14, 15, 16)*.[1] We extend the investigation by applying current time series methods to time series data frequently used in agricultural supply analysis where detrending, by including time as an independent variable in supply response equations, is common practice. We question both the use of time as a proxy for technological change and time-associated coefficients as a measure of technical change or as an indicator of dynamic movements in the production system.

We discuss specification of time as an independent regressor in supply response equations, statistical analysis of time series, and different methods for decomposing time series data. The procedure is to make alternative stationarity assumptions (trend stationarity or difference stationarity) on the statistical structure of regression residuals. Our purpose is to develop an analytical framework for assessing the validity of *a priori* stationarity assumptions. We apply a test proposed by Dickey and Fuller *(3)* to time series data for yield response changes and acres planted for three major crops: corn, wheat, and soybeans. The results of this test suggest a lack of adequate diagnostic analysis of time series data used in studies of supply response. Trend stationarity, as a maintained hypothesis, is tenuous, producing statistical results that may be misleading. We consider the implications of structural misspecification and the possibility of spurious results from inappropriate stationarity assumptions.

Supply Response Analysis

Many models that analyze agricultural supply response contain a linear trend term as an independent regressor. The justification often given for including trend terms is their perceived ability to capture the effects of omitted or unmeasurable variables, which are thought to have an effect over time. The omitted variable is frequently assumed to be technology, suggesting smooth deterministic changes in technology and bounded uncertainty as opposed to irregular stochastic changes with unbounded uncertainty *(14)*. Specification of a functional dependence on time implies an assumption by the investigator of trend stationarity. We suggest, however, that this assumed functional dependence is an empirical question and that *a priori* assumptions about the stationarity of any particular time series and the nature of technical change and future uncertainty are ad hoc. Incorrect stationarity assumptions have serious consequences. We show how they lead to spurious regression results and erroneous conclusions about the nature and magnitude of uncertainty and technical change.

Analysts of agricultural supply response generally separate crop production into two categories: yield response

The authors are agricultural economists with the Resources and Technology Division, ERS.

[1] Italicized numbers in parentheses refer to items in the References at the end of this article.

and acreage response. Examples of studies that consider yield response include Menz and Pardey *(12)*, Houck and Gallagher *(8)*, Reed and Riggins *(17)*, Butell and Naive *(1)*, and Lin and Davenport *(11)*. These studies use models that specify yield per acre as a deterministic function of time. The trend variable is assumed to measure technical change *(10)*. Reed and Riggins *(17)* also employ a difference specification after discovering that the trend term explains most of the variation in corn yields.

Models of supply response that analyze acres planted as the dependent variable in the regression include, Houck and others *(7)*, Gardner *(5)*, Houck and Ryan *(9)*, Morzuch and others *(13)*, and Ryan and Abel *(18)*. Again, time is included as an independent regressor in the acreage response equations, because "inclusion of the trend variable (T) had the effect of increasing the t-values for the individual variables and improving the overall fit of the equation as compared with specifications not including T" (*7*, p. 17). Trend is also included to "account for changes occurring through time which are not reflected by other variables" (*9*, p. 190).

Statistical Background

Modeling time series data is fundamentally a choice between two hypotheses about the data-generation process. We specify technical aspects of model specification without regard to any particular time series and show with a simple example that improper assumptions about the stationarity of a time series can have serious consequences, including unbounded forecast errors and uncertainty. We specify the most elementary representations of statistical time series, namely, first-order trend stationary (TS) processes and first-order difference stationary (DS) processes *(14)*. Extensions to higher order cases are discussed by Nelson and Plosser *(16)*, but Dickey and Fuller's tests *(2, 3)* are applicable only to the first-order cases presented here.

Consider the sequence $\{y_t\}$ of an observed nonstationary time series. If the nonstationarity in $\{y_t\}$ is assumed to be a linear dependence on time, then a model explaining the variation in y is properly specified as:

$$y_t = \alpha + \beta t + u_t \tag{1}$$

where $\{u_t\}$ is the stationary cyclical component of the variation in equation 1 and is assumed to be independently and identically distributed with zero mean and constant variance, and α and β are fixed paramenters. An alternative to equation 1 is to assume that y is stationary in first differences, for which the correct specification is given by:

$$y_t - y_{t-1} = \beta + e_t \tag{2}$$

where $\{e_t\}$ is a stationary series of independently and identically distributed random disturbances with zero mean and constant variance, and β is a fixed parameter. Equations 1 and 2 are alternative versions of a first-order transformation of nonstationary time series from which a stationary sequence of residuals is obtained. Equation 1 is a linear TS specification, and equation 2 is a first-order DS specification.

We can illustrate the fundamental difference between 1 and 2 by rewriting equation 2 as a recursive system:

$$\begin{aligned} y_t &= y_{t-1} + \beta + e_t \qquad (3)\\ y_{t-1} &= y_{t-2} + \beta + e_{t-1} \\ y_{t-2} &= y_{t-3} + \beta + e_{t-2} \\ &\vdots \end{aligned}$$

Successive substitution to some point in time, say y_0, yields:

$$y_t = y_0 + \beta t + \sum_{i=1}^{t} e_i \tag{4}$$

which is the result of expressing a first-order DS process as a linear function of time. Although equations 1 and 4 are similar in appearance, they are fundamentally different. One difference is in the intercept term; the intercept in equation 1 is a fixed parameter, whereas the intercept in equation 4 depends on the arbitrary determination of y_0 *(14)*. The error structure of the two equations is also different; equation 1 has a stationary error structure, but equation 4 has a nonstationary error structure because it is dependent on time. We can easily show this nonstationarity by computing the variance of the residuals in 4 as:

$$\begin{aligned} V(e_t) &= E[e_t - E(e_t)]^2 \\ &= E[\Sigma\, e_i^2] = e_1^2 + e_2^2 + \cdots + e_t^2 \qquad (5) \\ &= t\sigma_e^2 \end{aligned}$$

Equation 5 is an important result because it shows that a first-order DS process expressed as a linear function of time will yield confidence intervals that increase without bound *(14)*. The problem, however, is far more serious than unbounded confidence intervals. Nelson and Kang *(15)* investigate the problem of inappropriate detrending of time series and find it "to produce evidence of periodicity which is not in any meaningful sense a property of the underlying system" (*15*, p. 742). Their

results "further suggest that the dynamics of econometric models estimated from such data may well be wholly or in part an artifact of the trend removal process" (*15*, p. 742). They later show, through a decomposition of R^2, that the significance of coefficients from regressions of a random walk on time will be overstated and that R^2 "will exaggerate the extent to which movement in the data is accounted for by time" (*14*, p. 74). The reported t-statistics for the OLS coefficients on time for data generated by our equation 2 and modeled as equation 1 are striking results of their Monte Carlo experiments. Nelson and Kang's results reject the hypothesis of no functional dependence on time in 87 percent of the cases for samples of 100 observations at a 5-percent level of significance. The hypothesis of no functional dependence on time is rejected in spite of the fact that no such time dependence actually exists. It is similar to the spurious regression phenomena discussed by Granger and Newbold (*6*, sec. 6.4). Granger and Newbold show that conventional t-statistics can indicate a high degree of fit when one independent random walk is regressed on another.

Spurious regression results are a danger when time series data are detrended because the detrending procedure tends to remove much of the variation from the data (see *16*). Because random walk data often have the appearance of movement around a trend, it may seem reasonable to apply detrending procedures to achieve stationarity in the residuals. The result, however, is not a stationary sequence of residuals, but the removal of about 86 percent of the stochastic variation in the data *(14)*, and the attribution of that variation to assumed deterministic phenomena such as technical change.

Dickey and Fuller have developed formal procedures for testing time series specifications *(2, 3)*. Each specification, TS and DS, is treated as one side of a mutually exclusive hypothesis and is combined into a single model. One can write a model for testing the TS vs. the DS hypothesis for our simple example by combining equations 1 and 2 as:

$$Y_t = \alpha + \beta t + \phi Y_{t-1} + e_t \qquad (6)$$

and testing the null hypothesis, $\phi = 1$, $\beta = 0$ (*16*, p. 144). Failure to reject the null hypothesis indicates an underlying DS process, whereas rejecting the null hypothesis implies an underlying TS process *(16)*. Dickey and Fuller *(2)* represent the limiting distribution of $\hat{\phi}$, and they derive a test statistic $t(\hat{\phi})$ for testing this hypothesis. Critical values are tabulated and presented in Fuller *(4)* for the one parameter test, and in Dickey and Fuller *(3)* for the likelihood ratio test on the entire parameter space where the null hypothesis is $(\hat{\alpha},\hat{\beta},\hat{\phi}) = (\alpha,0,1)$.

The Dickey-Fuller test indicates model stationarity under the alternative hypothesis presented because it determines statistically the probability of a unit root in the characteristic equation of the model. In our simple model, the value of ϕ in equation 6 must be estimated and compared with the hypothesized value. If ϕ in equation 6 is significantly different from 1, then $\{y\}$ is a sequence that is stationary in trend, while also exhibiting autoregressive behavior. However, if ϕ is equal to 1, the indication is nonstationary behavior characterized by a unit root in the characteristic equation, and equation 6 reduces to a random walk with drift under the null hypothesis. Test statistics for the OLS estimator for ϕ do not conform to standard statistical distributions because the distribution centers about 1 and not zero.

Test Results

We apply the Dickey-Fuller test of the TS vs. the DS hypothesis to aggregate U.S. Department of Agriculture data for total crop yield and acres planted for corn, soybeans, and wheat. Data are annual and observations are continuous for 1930–86. The table shows results of the Dickey-Fuller test for both yields and acres planted. For the yield data, the null hypothesis HO: $\phi = 1$ was rejected at the nominal 0.05 level[2] in all cases. The test statistic for samples of 50 is −3.50, but for samples of 100 is −3.45. Thus, the true test statistic for our sample is between these two values. The yield data imply an underlying TS-generating process and suggest that the appropriate specification is one that involves a deterministic function of time. Results for acreage-planted data were the opposite. We were unable to reject the null hypothesis in any case at the nominal 0.05 level. The disagreement in these results requires further scrutiny.

Results of testing for autoregressive unit roots

Item	Parameter estimate	Standard error	Dickey-Fuller test statistic
Crop yield:			
Corn	0.350	0.129	−5.04
Soybeans	.015	.138	−7.14
Wheat	.528	.113	−4.18
Acres planted:			
Corn	0.783	0.086	−2.52
Soybeans	.860	.066	−2.12
Wheat	.807	.081	−2.38

Researchers who chose to model yields as a deterministic function of time make the correct *a priori* assumption, and those who chose to model acreage planted as

[2] In this case, the 0.05 level of significance is a stronger condition because the greater the significance level, the smaller the test statistic must be to maintain the null hypothesis.

a deterministic function of time do not. However, these results can be explained in terms of the underlying assumptions of the TS and DS specifications. The critical assumption involves the nature of the technological change that the dynamic model is postulated to capture. If technology does in fact change in a relatively smooth way, it is reasonable to assume a TS process.

Technological change in agriculture can be characterized as a TS process because of active and independent research and innovation related to output-enhancing inputs. Unlike many other types of production technology, agricultural technology is funded by both the private and public sector. Many assets in agriculture also have a relatively short span of productivity: 1 week, 6 months, a few years. Therefore the turnover in assets is rapid in contrast to heavy industry where plants and equipment may have an economic life of 25 years or more. Furthermore, complements of inputs in agricultural production are constantly changing, component by component, giving the effect of smooth changes in output. For example, a major breakthrough in seed technology may be followed by an improvement in fertilizer, which in turn is followed by an advance in herbicides, and so forth. Therefore, one could argue that aggregate yields for corn, soybeans, and wheat have increased along a deterministic trend.

Acreage planted, in contrast, is more a function of uncertain policy changes from one farm bill to the next and of prices and price expectations. These effects are likely to be random. Therefore, data for acres planted would likely follow a DS specification. This observation is particularly disturbing in light of the discussion of spurious regression phenomena provided by Nelson and Kang *(14, 15)* because several studies *(5, 7, 9, 13, 18)* employ a TS specification when analyzing acreage response. Nelson and Kang's argument leads to the conclusion that results from an inappropriately detrended series can provide seriously misleading information about the relationship between changes in farmers' decisions and changes in policies. These behavioral changes may be wholly unrelated to technical change, but largely attributed to it. Thus, technical change is given a role in policymaking that is unwarranted and unwise.

Conclusions

From the simple diagnostic example presented here, we have shown that the analysis of policy decisions over time and the evaluation of technical change and uncertainty, are closely linked to the assumptions and methodologies employed. This linkage is particularly true when longrun projections are being considered, because model misspecification implies unbounded uncertainty in future time. Researchers concerned with the accuracy of information generated for policy analysis must consider the consequences of *a priori* assumptions about data-generating processes. Far more work is needed to resolve these methodological issues so policy analysis can be improved.

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Book Reviews

Cross-over in International Economics

Real-Financial Linkages Among Open Economies. *Edited by Sven W. Arndt and J. David Richardson. Cambridge, MA: MIT Press, 1987, 215 pp., $27.50.*

Reviewed by Maureen Kilkenny

There are two camps in international economics. Both are concerned with relative prices. The international trade theorists are interested in the relative prices of goods among countries at one point in time. They try to explain patterns of trade by differences in factor endowments, technology, tastes, and other structural parameters. The international macroeconomists study the relative prices of assets over time. They try to explain currency exchange rates by international differences in interest rates, money supplies, and other financial variables. The first camp has relied largely on theoretical propositions, while the latter is ripe with stylized facts estimated from semi-reduced-form models.

Arndt and Richardson present eight papers by representatives from both camps who have crossed over to the other side. The trade theorists search for stylized facts from aggregate data, and the international macroeconomists base their reduced forms on structural, sectorally disaggregated models. The results are informative, innovative, and inspiring.

About two-thirds of the collection will directly interest the agricultural economist studying the relationship between international agricultural prices and the dollar exchange rate. What do exchange rates have to do with competitiveness? What caused exchange rates to appreciate? Is there a way to short-circuit the negative impact of currency appreciation on export demand? Is the volume of trade adversely affected by exchange rate volatility? These are some of the questions addressed.

The introductory overview contains concise explanations of the Law of One Price, Purchasing Power Parity, basic measures of competitiveness), and the nontradeable/tradeable price-relative version of the real exchange rate. Some knowledge of the literature is presumed, but the explanations are simple and clear. Just the right number of equations and graphs are used. The overview provides a unifying framework, relating all the models to the same basic structural assumptions. The papers on intertemporal and asset market linkages are also related to the papers on goods markets through the relative price theme.

Krugman and Marston provide two particularly interesting contributions. Krugman presents a study relating international price formation to market structure. An exporter with market power can avoid passing exchange rate increases to the export market by reducing nominal prices (in terms of their own currency). Marston asks how different rates of productivity growth among sectors can affect measures of international competitiveness. He shows that the real exchange rate in the United States reflected the relative rates of productivity growth between traded and nontraded sectors of the U.S. economy relative to those of Japan, but not the other way around. One consequence is the persistent trade deficit with Japan. Since the U.S. agricultural sector is both important in trade and shows high productivity growth, these types of linkages may be critical to agricultural economists.

Hutchinson and Pigott present a clear story of how a government deficit (not accompanied by monetary accommodation) puts pressure on domestic aggregate demand, worsens the current account balance, increases the interest rate, and causes exchange rate appreciation. Sound familiar? They study 10 industrialized economies and show that the United States is a textbook case where goods-market effects dominate.

The papers include: (1) "Real-Financial Linkages among Open Economies: An Overview" by Sven W. Arndt and J. David Richardson, (2) "Some Interactions between Goods Markets and Asset Markets in Open Economies" by Alan C. Stockman, (3) "Pricing to Market When the Exchange Rate Changes" by Paul Krugman, (4) "Real Exchange Rates and Productivity Growth in the United States and Japan" by Richard C. Marston, (5) "The Assessment of National Price Levels" by Irving B. Kravis and Robert E. Lipsey, (6) "Real and Financial Linkages in the Macroeconomic Response to Budget Deficits: An Empirical Investigation" by Michael M. Hutchinson and Charles A. Pigott, (7) "Monetary, Financial, and Real Effects of Yen Internationalization" by Koichi Hamada and Akiyoshi Horiuchi, (8) "Long-Run Exchange Rate Variability and International Trade" by Paul De Grauwe and Bernard de Bellefroid.

The reviewer is an economist, formerly with the National Aggregate Analysis Section, Agriculture and Rural Economy Division, ERS, and now a visiting assistant professor in the Department of Economics at The Pennsylvania State University.

De Grauwe and de Bellefroid show that the decline in the longrun rate of growth in bilateral international trade since 1973 is positively related to exchange rate variability, slower growth in gross national product, and less trade integration. Thus, not only do the levels of relative prices matter, but so do the variances.

The collection covers only a subset of the many linkages between real and financial markets both within and among open economies. The fundamental relationships between exchange rates, budget deficits, and international competitiveness are posited as testable hypotheses and are successfully analyzed. An obvious omission, of interest to agricultural economists, is an analysis of the asset characteristics of commodity futures markets. The editors suggest that their book is a first step toward filling an analytical and empirical gap. Agricultural economists who read this book should be inspired to contribute to the next steps.

Trade Theory versus the Real World

***Empirical Methods for International Trade.** Edited by Robert C. Feenstra. Cambridge, MA: MIT Press, 1988, 322 pp., $30.*

Reviewed by Chinkook Lee

Because international trade theory typically deals with $2 \times 2 \times 2$ models (two countries, two goods, and two inputs), empirical analysts face difficulties with nonhomogeneous data across countries and problems of data aggregation. The U.S. current account trade deficit has recently soared. Yet economists' efforts to use theory to shed light on real world issues flounder because of the lack of solid empirical work.

Feenstra's book is timely, dealing with theory, research methods, and empirical analysis. It brings together a wide range of empirical studies applied to three main topics of trade: (1) a cross-country analysis of testing the Heckscher-Ohlin-Vanek (HOV) trade models, (2) differentiated products and imperfect market structure, and (3) the use of duality in extending the estimation of production and cost functions to incorporate trade flows.

The theoretical and methodological analyses in each article are followed with empirical studies and comments by well-known trade economists. This format of empirical methods, empirical studies, and comments provides a helpful guide to the usefulness and shortcomings of research methods in empirical studies. The references focus on empirical studies of international trade.

Four studies test the HOV model of international trade theory. Brecher and Choudhri, who examine the HOV model for Canada and the United States, find no empirical support for it. Although their empirical findings are contrary to the received theory of international trade, their study is still a welcome addition to the limited number of studies that have actually tested the theorem. Dollar, Wolff, and Baumol find evidence contradicting the HOV model of trade as well. They find that, for the average industry, the cross-country labor productivity differential is strikingly large. U.S. labor productivity, for example, exceeds the United Kingdom's productivity in all but one of 28 industries examined. In 14 industries, the U.S. advantage is greater than 50 percent, and the productivity differential is more than 100 percent in 5 industries. This evidence suggests that the factor price equalization model is not a useful way to think about the issue of cross-country differences in labor productivity, because when one draws a connection between productivity and living standards, a 50-percent differential is clearly a large one.

Empirical studies are particularly deficient regarding the effects of trade barriers on income distribution. Addressing this deficiency, Leamer proposes a cross-section econometrics study that could reveal the output effects of tariff barriers. It could also be used to infer the effects of explaining trade flows based on taste differences across countries by relaxing one of the standard HOV assumptions: no taste differences between countries.

The reviewer is an agricultural economist with the Agriculture and Rural Economy Division, ERS.

The papers include: Section I—Cross-Country Analysis: The Heckscher-Ohlin Model and Beyond. (1) "The Factor Content of Consumption in Canada and the United States: A Two-Country Test of the Heckscher-Ohlin-Vanek Model" by Richard A. Brecher and Ehsan U. Choudhri, (2) "The Factor-Price Equalization Model and Industry Labor Productivity: An Empirical Test across Countries" by David Dollar, Edward N. Wolff, and William J. Baumol, (3) "Cross-Sectional Estimation of the Effects of Trade Barriers" by Edward E. Leamer, (4) "Per-Capita Income as a Determinant of Trade" by Linda C. Hunter and James R. Markusen.

Section II—Industry Studies: Product Variety and Imperfect Competition. (5) "Gains from Trade in Differentiated Products: Japanese Compact Trucks" by Robert C. Feenstra, (6) "Optimal Trade and Industrial Policies for the U.S. Automobile Industry" by Avanash Dixit, (7) "Market Access and International Competition: A Simulation Study of 16K Random Access Memories" by Richard E. Baldwin and Paul R. Krugman.

Section III—Dual Methods: Aggregate Technology, Prices, and Trade Flows. (8) "Export Supply and Import Demand Functions: A Production Theory Approach" by W. Erwin Diewert and Catherine J. Morrison, (9) "International Factor Mobility and the Volume of Trade: An Empirical Study" by Kar-yiu Wong. (10) "Multilateral Index Numbers" by Bee Yan Aw and Mark J. Roberts, (11) "Productivity Growth and Changes in the Terms of Trade in Canada" by Alexandra Cas, W. Erwin Diewert, and Lawrence A. Ostensoe.

Four more studies deal with what Krugman calls "new theories" of trade among industrial countries. Although the factor-endowment model continues to play a prominent role in trade theory, it does not adequately account for world trade flows, particularly for manufactured goods. Thus, economies of scale, market imperfection, and other theories drawn from industrial organization literature have been used in empirical studies.

Baldwin and Krugman considered competition between the United States and Japan in random access memories (RAM's) in computers. Recent work on international trade policy in the presence of imperfectly competitive markets has pointed out a number of theoretical possibilities for strategic trade policy with potential benefits for the United States. Among these benefits is the possibility that, for a dynamic industry such as semiconductors, where U.S. firms have economies of scale, import protection may have been the key to Japanese success. If Japan and the United States had engaged in a "trade war" in RAM's, firms would have been smaller and would have had higher marginal costs. The resulting higher prices in both markets, especially in the smaller Japanese market, would have reduced welfare in both nations because of the increased costs of RAM's.

Four studies deal with duality theory, measuring aggregate relationships among technology, prices, and trade flows. Cas, Diewert, and Ostensoe measured the growth in Canada's total productivity and changes in the terms of trade for 1961–80 by using the Canadian input-output table. Two applied welfare questions interest the authors. First how did productivity growth enhance Canada's total welfare? Second, and more important, how did total welfare change as a result of shifts in Canada's terms of trade? The authors' empirical findings indicate that Canadian welfare increased about 48 percent. During the sixties, welfare growth was based entirely on productivity growth. During the seventies, however, welfare growth was split; 40 percent came from productivity growth and 60 percent from favorable terms of trade.

I think the relative factor endowment and factor-price equalization theory continues to play a prominent role in trade theory. Thus, I found the first section of the book the most interesting. Suppose that we are interested in testing this theory empirically. Then, we are immediately faced with a formidable aggregation problem. Each good in the two-by-two model is not literally a single good, but is usually interpreted as an aggregate, such as agriculture, manufacturing, or imports and exports. Because of the difficulty of constructing such aggregate data, even the most diligent researchers hesitate to do an analysis. One reason why Leontief's empirical study became famous was because he was the first to tackle this problem.[1] Leamer's landmark study of the empirical analysis of international trade[2] is also a major addition to the study of the importance of factor endowment and factor-price equalization theory. A recent article by Bowen, Leamer, and Sveikauskas further demonstrates the continued interest in the factor endowment and factor-price equalization theory of trade.[3]

The studies in the first section of Feenstra's book cover the theoretical development of HOV, modifying and refining the model in light of constraints posed by data availability for many countries. Each author confesses that the constraints posed by the data limit the findings, which shows how difficult it is to test the HOV model empirically. Assumptions made by HOV are hard to apply to real world situations. However, we have not found enough evidence to deny that the *sources* of international comparative advantage are in relative factor endowments. Thus, the heart of empirical work is still the cross-country analysis of net export commodity trade and resource endowments, which is why the studies in the book's first section are so interesting.

A major limitation of the book is its lack of coverage of how macroeconomic shocks affect international trade and terms of trade. Such shocks include large changes in world capital flows, major swings in balance-of-payments accounts, and major changes in world trade patterns. A few questions remain: Are exchange rates excessively volatile? How does currency depreciation affect relative prices, export and import demand, and U.S. competitiveness in international trade? Many of these shocks have altered the composition of demand and supply. It now appears there are wide gaps among theory, methodology, and empirical practice. A treatment of computable general equilibrium models, which can be used to sort out the direct and indirect links through which macro shocks affect the system, would have been a useful addition to the book. Nevertheless, students of international trade will find much of value in it.

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[1] W.W. Leontief, "Domestic Production and Foreign Trade: The American Capital Position Re-examined," in *Proceedings of the American Philosophical Society,* Vol. 97, Sept. 1953, pp. 332–49.

[2] Edward E. Leamer, *Sources of International Comparative Advantage,* Cambridge, MA: MIT Press, 1984.

[3] Harry Bowen, Edward E. Leamer, and Leo Sveikauskas, "Multicountry, Multifactor Tests of the Factor Abundance Theory, "*American Economic Review,* Vol. 77, p. 5, Dec. 1987, pp. 791–809.

Sustainable Development

Sustainability Issues in Agricultural Development, *Proceedings of the Seventh Agriculture Sector Symposium. Edited by Ted J. Davis and Isabelle A. Schirmer. Washington, DC: The World Bank, 1987, 382 pp., $23 (paper).*

Reviewed by Folke Dovring

When an institution as prestigious as the World Bank collects a set of papers and then disclaims any responsibility for the result, one has to wonder. Give the bank marks for honesty, at least. To be fair, the papers are intended to bring readers up to date on thinking within the bank and to propose new lines of thought, work, and investment. The book reflects the bank's ambition to exchange knowledge with other leaders working on agricultural development.

Failures of World Bank projects to produce durable results are discussed by David Hopper (World Bank) and Francis Idachaba (University of Ibadan, Nigeria). They neither conceal problems nor offer false excuses. With their directness, they set the tone for other papers, which range from institutional requirements and natural resource management to diversification of production.

Many of the detailed problem analyses are excellent and contain a wealth of information from World Bank experience. Although the bank disclaimed responsibility for minor errors, the reader should be advised that some content has been omitted (for example, between pp. 25-26, 75-76, and 352-53).

The title, reflecting the tendency to give substance to abstractions, is a source of inconsistency. "Sustainability" is not a thing or even an unambiguous category. Like beauty, "sustainability" means so many things that in the end it risks meaning nothing in particular.

The difficulty with "sustainability" is more than semantic. Ambiguity in the central term of the book affects its comprehensibility. The slippery meaning of sustainability fosters conflicts that run deep throughout the volume. The least of the difficulties is the blurring of the distinction between what is sustainable and what is sustained. "Sustainable" refers to what should be expected, given the professional and administrative competence brought to bear on projects. "Sustained," by contrast, includes failures because of lack of attention to detail, inability to cope with minor contingencies, political ins and outs, and "acts of God." The first paper focuses on failures due to World Bank shortcomings, whereas the second speaks mainly to African politics.

Authors Idachaba and Hopper should have distinguished between growth as a mere expansion of current techniques and the development of new techniques leading to higher production functions. Idachaba discusses mainly growth, Hopper mainly development. The problems of sustaining each are not the same; they are more exacting in cases of development because of the element of innovation that calls for more systemic analysis than is needed for growth, if the latter is taken as a matter of mere quantity.

The larger difficulty, which is only partly articulated, is sustaining income within a conventional accounting horizon and preserving natural resources into the indefinite future. When the editors place the papers on institutions before those on natural resources and diversification, they emphasize conventional accounting principles. If that kind of planning horizon is accepted, the conclusion is undoubtedly correct, as sketched by Hopper and developed in competent detail by Ruttan. The major failure of the World Bank's investment projects has been an almost complete disregard of institutions that render impractical many projects devised from the standpoint of developed countries rather than the target country.

What is an "appropriate technology"? Either the project includes a technology that the country can use, given current conditions, or it adopts a technology that fits in with the institutions and the culture (and the factor proportions, of course). Or, each project is made to include proposals for institutional and cultural innovations, where they are deemed feasible, to render the technological innovation realistic. One way or the other, many of the bank's projects have failed because of one-sided emphasis on technology. The composition of the bank's staff reveals this kind of thinking; it has almost no expertise in sociology.

The reviewer is a professor of land economics (emeritus) in the College of Agriculture, University of Illinois, Urbana-Champaign.

The papers include: (1) "Sustainability, Policies, Natural Resources, and Institutions" by David Hopper, (2) "Policy Issues for Sustainability" by Francis Idachaba, "Institutional Requirements for Sustained Agricultural Development" by Vernon Ruttan, (3) "Human Development and Sustainability" by Bernard Woods, (4) "Local Government and Local Institutions" by Samuel Paul, (5) "Making Ministries More Effective" by Bowman Cutter, (6) "Agricultural Marketing Institutions and Privatization" by Martin Staab, (7) "Farmers Organizations and Institution Building for Sustainable Development" by Michael M. Cernea, (8) "Issues in Research and Extension" by John A. Hayward, (9) "Managing Natural Resources for Sustainability" by Robert Repetto, (10) "Soil Conservation and Small Watershed Development" by Pierre Crosson, (11) "Land Management, Tilting, Tenancy" by Francois Falloux, (12) "Farm Forestry" by Michael Arnold, (13) "Desertification" by David Steeds, (14) "Salinity Management Issues" by Walter Ochs, (15) "Preservation of Germplasm" by John A. Pino and Michael S. Strauss, (16) "A Re-evaluation of Approaches to Fisheries Development: The Special Characteristics of Fisheries and the Need for Management" by Francis T. Christy, (17) "Diversification Issues in Sustainable Production Systems" by Donald Winkelmann, (18) "Diversification from Rice" by Richard Reidinger, (19) "Crop Diversification in Irrigated Agriculture: Water Management Constraints" by Herve Plusquellec, (20) "Commodity Analysis for Diversification" by Ronald Duncan, (21) "Research and Extension Needs for Diversification" by Donald Plucknett, (22) "Upstream Needs (Information, Inputs and Credits) by Handy Eisa, (23) "Post-Harvest Considerations for Diversification" by James G. Brown, (24) "Economic Policy for Diversification" by Peter Hazell, (25) "Some Thoughts on Economic Development, Sustainability, and the Environment" by G. Edward Schuh.

The emphasis on technology may explain why the bank has done almost nothing to redeem the pledge in McNamara's Nairobi speech (1973) to help in land reform. Peasant mores remain little understood. Like other innovations, those of institutions also need to be "appropriate," that is, they must be able to fit in with the culture. Failure to do so is not limited to international organizations. National governments have failed just as much, as reflected in a recent report from India about "grass without roots." The article on titling and tenancy (placed among those on natural resources) emphasizes formal land register, even though it is far less relevant to landowning peasants than it is to governments and absentee landlords.

The greatest difficulty in the book is the conflict between projects for current production and long-term care of natural resources and the environment. This conflict is a reason the bank's projects have been criticized. Repetto's article, and several others, emphasize the failure of development projects to assess resource deterioration and environmental damage. Winkelmann's article suggests some possible remedies. The difference in planning horizon, however, is sometimes overshadowed by other matters. For example, the effects of soil erosion on land productivity are masked by increasingly intensive use of fertilizers and pesticides.

Above all looms an intergenerational conflict. How much does the present generation owe future generations? Some theorists say the future is not worth saving. Many people in poor countries say they cannot afford luxuries such as conservation and environmental protection. They are too preoccupied with immediate growth and development. If resources in the tropics are to be conserved, let the rich countries pay for it, so some of the recent debate says.

Stripping the jungles in Brazil or burning the coal in China can affect the whole ecosphere, including that of the temperate regions. The bank's proceedings offer no major solutions, but one might conclude that we need a new departure in foreign aid—toward more multilateral international aid—to harmonize the growth and development strategies of the poor countries and the ecological concerns of the whole world.

If the predicted ecological disasters are to be prevented, the World Bank and the other international agencies may have to embark on a new and more comprehensive program, one requiring new institutions, cultural adjustments, and nonconventional development projects.

Some Practical Perspectives on Food Demand Analysis

Food Demand Analysis: Problems, Issues, and Empirical Evidence. *Edited by Robert Raunikar and Chung-Liang Huang. Ames: Iowa State University Press, 1987, 285 pp., $23.95.*

Reviewed by Robert J. Hauser

Raunikar and Huang, under the aegis of regional project S-119, have assembled an excellent set of papers describing how empirical research on food demand fits into or departs from traditional demand theory. The 28 papers sometimes resemble a "collection of readings," but the editors and authors do a good job of tying the chapters together and showing relationships among methodological approaches. The most important contribution of the book may be its excellent summary of data sources and problems.

Readers will obtain a good idea of what has been traditionally done in the areas of partial- and complete-demand modeling. Missing, however, are discussions on what needs to be done and on recent modeling efforts using nonparametric methods.

The book will be useful to researchers of food demand and to instructors of graduate-level courses in demand analysis. The data, theory, and illustrations will serve a wide audience.

Capps and Havlicek present a theoretical backdrop to subsequent chapters on partial and complete demand systems in which they review concepts of neoclassical demand. They also discuss empirical issues that are not conducive to neoclassical description as well as methodological issues that demand analysts face. Although most issues are adequately covered, the question of why researchers ignore supply when conducting empirical studies of consumer prices and consumption probably does not receive enough attention.

The nine coauthors of chapter 2 identify various data sources, collection methods, and common problems encountered when researchers work with price, expenditure, and quantity data. Bobst and Buse then illustrate the use of disappearance data and consumer expenditure surveys.

The reviewer is an associate professor of agricultural economics at the University of Illinois, Urbana-Champaign.

Those first three chapters are particularly useful to professionals and graduate students who are attempting to define a practical context for empirical demand analysis. Furthermore, they provide considerable reference material that cannot be obtained from typical research reports.

The papers include:

Part I—Theory and Data for Demand Analysis (1) "Concepts of Consumer Demand Theory" by Oral Capps, Jr., and Joseph Havlicek, Jr., (2) "Data Sources for Demand Analyses" by Barry W. Bobst, Robert E. Branson, Richard C. Haidacher, Eva E. Jacobs, Robert Raymikar, Benjamin J. Senauer, David Smallwood, Daniel S. Tilley, and Lillian R. de Zapata, (3) "Data Problems in Demand Analyses: Two Examples" by Barry W. Bobst and Rueben C. Buse.

Part II—Complete Demand Systems (4) "Comparison of Estimates from Three Linear Expenditure Systems" by John A. Craven and Richard C. Haidacher, (5) "Persistence in Consumption Patterns: Alternative Approaches and an Application of the Linear Expenditure System" by Richard Green, Zuhair Hasan, and Stanley R. Johnson, (6) "Analysis of Household Demand for Meat, Poultry, and Seafood Using the S1-Branch System" by Oral Capps, Jr., and Joseph Havlicek, Jr., (7) "Analysis of Food and Other Expenditures Using a Linear Logit Model" by T. J. Tyrrell and T. D. Mount, (8) "Complete Demand Systems and Policy Analysis" by David B. Eastwood and Theresa Y. Sun.

Part III—Partial Systems: Factors Influencing Food Purchases (9) "Partial Systems of Demand Equations with a Commodity Emphasis" by Barry W. Bobst, Chung L. Huang, and Daniel S. Tilley, (10) "Socioeconomic, Demographic, and Psychological Variables in Demand Analyses" by James Blaylock, Rueben Buse, Jean-Paul Chavas, David W. Price, Dorothy Z. Price, David Smallwood, Donald A. West.

Part IV—Policy Issues Affecting Nutrition (11) "Consumer Demand for Nutrients in Food" by Karen J. Morgan, (12) "Food Consumption and Nutrient Intake Patterns of School-Age Children" by Karen J. Morgan and David W. Price, (13) "Impact of the Food Stamp Program on Food Expenditures and Diet" by Chung L. Huang, David W. Price, Ronald A. Schrimper, and Benjamin H. Senauer.

The rest of the book focuses on complete demand systems, partial systems of the food sector, and policy issues affecting nutrition.

Linear expenditure systems (LES) receive much attention in terms of specification, application, and illustration. The LES discussion is contrasted (especially by budget constraint implications) with an application of a linear logit model. Green, Hassan, and Johnson then illustrate some of the ways that estimates derived from complete demand models can be adapted to policy analysis.

Bobst, Huang, and Tilley outline some advantages of and practical needs for partial systems with examples for selected commodities.

The first three-fourths of the book (through the partial systems section) focuses heavily on issues of research methodology with examples of application. The final section, "Policy Issues Affecting Nutrition," departs from this general theme by defining a particular subject of study for the section (policy issues), and by not defining links between research methodologies and the theoretical discussion presented earlier.

Morgan begins the policy-issue section by briefly reviewing consumer demand with respect to product characteristics. She then focuses on the development of a predictive model for breakfast cereal prices. She never makes clear, however, why this study is closely related to "policy issues affecting nutrition" or how it could be used to make relevant generalizations about policy issues. The rest of the section focuses on the Food Stamp Program and on school lunches. Morgan and Price examine the diets of children in terms of nutrient contributions of cereals and levels of sugar and salt consumption. Relationships between socio-economic variables and nutrients are estimated, and the effects of school lunch and food stamp programs on nutrient intake are investigated. Huang, Price, Schrimper and Senauer summarize studies that have attempted to explain either participation in Food Stamp Programs or the effects of these programs on food expenditures, food prices, and diet.

Evolution of U.S. Drainage Policy from Development to Preservation

Farm Drainage in the United States: History, Status, and Prospects. *Edited by George A. Pavelis. MP-1455. U.S. Department of Agriculture, Economic Research Service, 1987, 170 pp., $9 (paper).*

Reviewed by Leon E. Danielson

The subject of land drainage has intrigued American farmers, agricultural researchers, and extension specialists since the early days of our country's settlement. Tales of horses wading through water "to their girth," of swarms of mosquitoes, and diseases such as malaria suggest the difficulties swamplands presented as the frontier moved westward. Drainage transformed this land into highly productive cropland. Today, drainage principles and practices often bear little resemblance to those of earlier days, and water management techniques and principles have become increasingly sophisticated.

A major portion of the book is devoted to tracing the evolution of these technological improvements, and it makes for interesting reading. Each article is an invited paper by an author known and respected in the field of drainage and water management. Six articles focus primarily on the technical aspects of drainage. Two major types of technical progress are identified: (1) changes in materials and installation methods, and (2) changes in the design of water management systems through use of computer simulation and design procedures. These studies will be of interest primarily to technically oriented readers, although only one of them requires considerable mathematical expertise.

As an addition to natural resources literature, the book's major contribution is its review of drainage policy and the transition from the "development ethos" characterizing U.S. policies for about 200 years after settlement to a policy embracing an "environmental ethic."

Observers of U.S. land and water policy might be tempted to consider four events or conditions in the mid-eighties as initiating the change in policy and the decline in the economic incentives to clear and drain wetlands: (1) passage of the swampbuster provisions of the 1985 Food Security Act, (2) the 1986 Tax Reform Act (new rules for taxing capital gains and expensing land development costs), (3) the high cost of farm commodity surpluses, and (4) an increased resolve to deal with high national budget deficits. However, Pavelis traces the beginnings of the "environmental ethic" back to the fifties. Financial assistance from the Agricultural Stabilization and Conservation Service under the Agricultural Conservation Program and technical assistance from the Soil Conservation Service were curtailed beginning in 1956 in cases where new land was brought into production. Other policies later played a major role: the National Environmental Policy Act of 1969, the Clean Water Act as amended in 1977, and President Carter's Executive Order on protection of wetlands (no. 11990 in 1977). Thus, these four events and conditions in the eighties actually completed a change in policy begun three decades earlier.

The authors also discuss policies that were important during the "development ethos" era. I found the concept of drainage at the "extensive" versus "intensive" margins useful in categorizing the effects of policies during the two eras. In the development era, policies expanded farmland at the extensive margin by bringing new lands into production. That is, they contributed to the dynamic process whereby lands move out of forest land or wetlands and into agriculture. Today, and in the future so long as drainage policies embrace the environmental ethic, policies will stimulate drainage at the "intensive margin," but will not stimulate expansion at the extensive margin. In this case, drainage will increase the intensity of farming by increasing production and net return on existing farms without converting land from other uses. Although some other industries such as forestry may not be limited to the intensive margin, the concept is useful in speculating about the level and the effects of drainage in the future.

Two articles, one by Fausey, Doering and Palmer, the other by Thomas, deal with assessing values associated with drainage. Topics range from traditional pro-drainage values (for example, public health and control of water-borne disease, salt removal, increased trafficability and timeliness in working the land) to public environmental values associated with preservation of wetlands (for example, fish and wildlife habitat, groundwater recharge, and nutrient retention). The articles on values are important because they recognize progress in accepting and bringing into the open the need for poli-

The reviewer is a professor in the Department of Economics and Business, North Carolina State University.

cies balancing public environmental costs with private benefits of drainage. Readers interested in the natural values of wetlands should consult other sources such as ecological texts for an indepth treatment of the topic.

Pavelis estimates the value of drainage by comparing land values in "highly drained counties" with those in counties classified as "less highly drained." The analysis suffers, however, because the data are not detailed enough to allow adjusting for other factors and conditions affecting land value that vary among counties or tracts. A far more detailed database is needed to estimate causal relationships between drainage and land values. The Swader and Pavelis article also contains information on wetland value, especially that related to natural values of wetlands as providers of waterfowl habitat. The information about values is good, but it suffers from being scattered.

The final major topic addressed might be labeled drainage data, trends, and expectations for the future. Pavelis, Daugherty, and Lewis, and Swader and Pavelis present useful national and State data on several topics: surface and subsurface acreage drained, land uses, drainage improvement investments, drainage and irrigation needs from the 1982 National Resources Inventory, value of production on irrigated lands, farmland values, and waterfowl values. The authors evaluate the adequacy of drainage information and add a cautionary note because comparable data seldom exist between studies done for different purposes or in different years. I found three errors in the data presented, and readers might want to look closely at the numbers.

Although the U.S. Department of Agriculture has often been criticized by environmental groups for its pro-agriculture stance in the past, the book documents just how far Federal policymaking has come in trying to reflect the public's interest in balancing agricultural development values and environmental values. Van Schilfgaarde writes that he expects this balance to continue and that improved policies in the future will enhance agricultural production and promote environmental values. However, history has shown that the winds of change often come swiftly. It is easy to imagine events (for example, a major drought in the United States or elsewhere) that could again swing the pendulum toward pro-development forces. Conversely, rapid technological gains in the future could further relieve the "pressures to produce" on America's farmland and thereby reinforce policy trends of the past 30 years. As Smith and Massey note, higher productivity from agricultural research and development facilitates the protection of environmentally sensitive lands by making their productive capacities less essential. Under such conditions, preservation of these lands is less controversial.

The book provides an interesting overview of the history of drainage and makes valuable suggestions for developing better policies to balance private and public wetland values. We may indeed be seeing the end of the era of strong USDA support for drainage activities, which may or may not lead to longrun changes in drainage activities and the preservation of wetlands. New policies are needed that provide economic returns to private landowners for maintaining wetlands in their natural state for the public's benefit. Improved methods of estimating the public values provided by wetlands may be required. Finally, new information collection schemes must be designed to provide accurate data so we can determine whether trends in wetland loss are changing.

The papers include: (1) "A Framework for Future Farm Drainage Policy: The Environmental and Economic Setting" by Stephen C. Smith and Dean T. Massey, (2) "A History of Drainage and Drainage Methods" by Keith H. Beauchamp, (3) "Advances in Drainage Technology: 1955–85" by James L. Fouss and Ronald C. Reeve, (4) "Purposes and Benefits of Drainage" by N.R. Fausey, E.J. Doering, and M.L. Palmer, (5) "Preserving Environmental Values" by Carl H. Thomas, (6) "Principles of Drainage" by R. Wayne Skaggs, (7) "Drainage System Elements" by Walter J. Ochs, Richard D. Wenberg, and Gordon W. Stroup, (8) "Planning Farm and Project Drainage" by Thomas C.G. Hodges and Douglas A. Christensen, (9) "Drainage for Irrigation: Managing Soil Salinity and Drain-Water Quality" by Glenn J. Hoffman and Jan van Schilfgaarde, (10) "Drainage Institutions" by Carmen Sandretto, (11) "Economic Survey of Farm Drainage" by George A. Pavelis, (12) "Drainage Potential and Information Needs" by Arthur B. Daugherty and Douglas G. Lewis, (13) "Drainage Challenges and Opportunities" by Fred Swader and George A. Pavelis.

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